

¹Nikola TRBOJEVIĆ, ²Ivana RIBARIĆ, ³Biljana VRANJEŠ

REDUCTION OF HAZARD LEVELS ON CNC MACHINES

¹Karlovac University of Applied Sciences, J.J.Strossmayera 9, Karlovac, CROATIA

²City of Sisak, Rimska 26, 44000 Sisak, CROATIA

³University of Banja Luka, Mechanical Engineering, S.Stepanovića 71, Banja Luka, BOSNIA & HERZEGOVINA

Abstract: Hazard places or spaces on the machines are places and spaces where can occur due to hazards movements: crushing, clamping, grabbing, cuts, bumps but and shocks of electrical energy and harmful effects of dangerous substances. For this purpose, work on CNC machining centers will be considered. Aim of this work was to raise awareness of the values and significance of the work safety system and presenting measures, activities and methods for removing and reducing the risk of working with CNC machines. Although, the CNC machine used more and more in almost all manufacture processes, it is good to explore the advantages and disadvantages of the machine and to prevent and avoid the dangerous situations of the same.

Keywords: CNC machine, safety and protection, risk, manufacture process

INTRODUCTION

In the metalworking industry, every device or tool is a potentially hazard to the worker. Hazard is greater if work equipment is not used in accordance with the Ordinance on the Use of Personal Protective Equipment and the Occupational Safety and Health Act and if used by persons who are not professionally qualified to work with them [1]. Particularly hazard is the processing of materials on metal cutting machines, wood processing, cutting tools, crushing of different materials, as well as any other kind of technological process where material particles are moving. These hazards are larger if they are materials or parts that have sharp parts or ends, for example, such as sheet metal, rod materials, gnawer, various types of knives for machines, tools and various other materials.

Hazard places or spaces on the machines are places and spaces where can occur due to hazards movements: crushing, clamping, grabbing, cuts, bumps but and shocks of electrical energy and harmful effects of dangerous substances [2]. For this purpose, work on CNC machining centers will be considered.

DISTRIBUTION ACCORDING TO PURPOSE

According to the purpose of CNC machining centers we can divide into universal and specialized.

— Universal CNC machines

Universal CNC machines are used in manufacturing where we have more types of products. Such machines should ensure that switching from one type of processing to another is simple and fast. They should provide a universal way to accept or fasten the fabric and to quickly and efficiently modify more or less universal processing tools.

Tools on such machines can usually be used in many types of processing and can be easily adapted to the desired processing.

— Specialized CNC machines

Specialized CNC machines are usually geared towards manufacturing with one type of product within which they can produce different types of products.

Such machines have specific characteristics in accepting the workpiece, but also in the type of tool they use. It should be noted that CNC machineries use a limited number of different types of machining in a CNC machine. As an example of specialized CNC machining centers, it is possible to specify those for the production of windows, shutters and door frames, edge trim machines and others.

WORKING ON CNC MACHINES

An employer may not make use of a machine that has not been manufactured in accordance with the rules on occupational safety, or is not in good working order and must be discontinued from use if changes occur which pose a risk to the life or health of the worker.

For the purpose of determining that the machine is manufactured in accordance with the rules on occupational safety, the employer is obliged to procure or issue the appropriate document as well as the instructions on machine operation, the way of assembly and dismantling, inspection and maintenance, and instruction of safe handling. However, as the machines are subject to possible modifications (damage to constructive elements, ineffective protection of protective devices due to inadvertent handling or the like) that may be a hazard to the life or health of a worker, the employer is obliged to carry out inspections and control of all machines used to determine whether they are whether the safety rules apply to the machinery and whether the life or health of the worker is not compromised due to the changes that have occurred.

This means that the employer is obliged to regulate the periodic inspections and controlling of machines for the purpose of assessing their correctness during use, by assessing the risks and/ or regulations on occupational safety. It is not enough for machines to be designed and manufactured in accordance with occupational safety rules, but they must be strictly intended for use, and workers should have instructions for safe operation with the machine in question. In order to do this, it is necessary to carry out constant inspections of the machines.

Therefore, in assessing the risk and/ or the rule book of occupational safety, the employer must accurately determine, on the basis of the machine analysis, all the elements necessary to standardize the examinations, such as:

- ≡ control elements,
- ≡ manner of conducting examinations or controls,
- ≡ review deadline,
- ≡ legal rate of write off and present value of the machine and
- ≡ who needs to be reviewed.

It must be emphasized that the prescribed time limits in the system of periodic examinations and controls can not and should not release the work tasks of those who undertake direct supervision during production. Also, this does not release the duties of regular machine control or workers who serve the machine [1].

— OPERATOR PROTECTION

Handling with any machine and even CNC machine can be hazards for an operator who oversees a specific machining process. CNC machines manufacturers try to minimize the risk of hazard through various construction solutions of the machine itself or by additional upgrades near the machine (various partitions, laser beams, cabs). Due to the operator position CNC processing can be divided into:

- a) CNC processing in open space, Figure 1,
- b) CNC Surface Processing, Figure 2.



Figure 1. CNC processing in open space



Figure 2. CNC surface processing

For outdoor CNC machining, the operator may be physically in contact with the rotation itself, but during the operation of the machine, it must be distanced to a certain distance, depending on the machine's safety specifications. Most commonly, in front of the work desk, there is a touch-sensitive carpet security that prevents the machine or machine part from being machined during machining. Some machines use a laser beam as a non-slip type machine, and if the machine stops working, the machine stops temporarily [2].

The advantage of using the carpet is in multiple zone processing, whereby one part of the machining unit is accessed to allow machining work to be fixed. During CNC processing in the enclosure, the operator is physically separated during machine operation, usually with a large window sliding door. This gives the operator full security. Closed space significantly reduces the amount of dust around the machine, which reduces the noise level.

— PLAN OF MEASURES

A plan of measures to reduce the level of danger when working with CNC machines is shown in Table 1.

Table 1: Plan of measures to reduce the level of danger when working with CNC machines

No.	Detected flaws	Proposal of basic and/ or special safety at work measures the employer must apply to eliminate the flaws or at least minimise as much as possible
1	Documentation	Follow the prescribed procedures, work instructions and legal regulations. Documentation inspection and updating.
2	Personal protection	Procure and use quality protective equipment. Control its integrity and use. Use survey list and representative sample.
3	Working premises	Working and busy premises clear from unnecessary items; keep tidy and clean.
4	Noise	When procuring new equipment, use certified machines and equipment. Perform periodical intensity checks.
5	Forbidden consumption of alcohol and other substances	Workers under the influence of alcohol are a hazard to the working environment. If necessary, introduce stricter and mandatory measures.
6	Safety at work training	The employer cannot allow a worker to perform unsupervised work without workplace safety qualifications. Immediately inspect workplace safety training programme.
7	Cleared walkways, passages for transport and evacuation of workers	Walkways and emergency exits must be kept clear and lead directly to open space or safe area. Emergency exit must not be locked. Evacuation passages must be marked.
8	Environmental protection	Compliance with prescribed procedures.

— INSTRUCTIONS FOR SAFE OPERATION WITH THE CNC MACHINE

The basic instructions for working safely are:

- ≡ Only a worker who is fit to work on this machine and who is qualified to work safely can work on the machine.
- ≡ When working on a machine, the worker is exposed to hazards of moving and rotating parts of the machine, returning or rejection of processing objects, flying pieces and particles, falling objects and the like, which can cause serious injuries.
- ≡ Before starting work, check the correctness of all parts of the machine, especially if all the moving parts of the machine are closed with a protective device.
- ≡ While the machine is forbidden to clean, lubricate or repair it.
- ≡ Only a worker who is fit to work on this machine and who is qualified to work safely can work on the machine.

- ≡ When working on a machine, the worker is exposed to hazards of moving and rotating parts of the machine, returning or rejection of processing objects, flying pieces and particles, falling objects and the like, which can cause serious injuries.
- ≡ Before starting work, check the correctness of all parts of the machine, especially if all the moving parts of the machine are closed with a protective device.
- ≡ While the machine is forbidden to clean, lubricate or repair it.
- ≡ Space around the machine must always be cleaned and access to the machine is free.
- ≡ The machine is forbidden to remove protective devices.
- ≡ During work, the worker must use personal protective equipment.
- ≡ During work, you should focus on work and not talk to other workers. Different joke and games around the machine are especially hazards as they can be a cause of injury. Before starting work, tighten your sleeves and secure them securely. Remove the scarfs, scarves and ties, rings, watches, bracelets and other items that could be sewn into machine parts and attach the hair.
- ≡ Secure the work object mechanically to the work desk.
- ≡ When working on a workpiece, stop the machine, secure it from unauthorized re-engagement, wait until all rotating parts are stopped, and then remove any interference.
- ≡ In the event of any malfunction of the machine or tool, the protective device or the activation device, the machine should stop and make the fault of the responsible operations manager.
- ≡ After turning off, the machine is a source of hazard for some time.
- ≡ Before switching off the control voltage and a machine that ensures unauthorized re-engagement, the machine can be repaired, lubricated and cleaned and repaired and cleaned in its immediate vicinity.

RIGHTS AND LIABILITIES OF EMPLOYER

The employer is obliged to organize and implement work safety, taking account of risk prevention and information, training, organization and means. All costs of carrying out workplace safety are borne by the employer, ie its implementation must not charge the worker.

The employer is obliged, taking into account the work and their nature, assessing the risks to life and health of workers and persons at work, in particular in relation to: the means of work, the working environment, technology, physical harmfulness, chemicals, or the biological agents it uses, arrangement work place, organization of the work process, work uniformity, statodynamic and psychophysiological efforts, work with imposed rhythm, work on the effect in a certain time (normative work), night work, psychological workload and other risks that are present in order to prevent or reduce risks.

The employer is responsible for organizing and enforcing the protection of workers. It is also obliged to identify and

perform occupational safety in accordance with the risk assessment, the state of occupational safety and number of workers.

The employer is obliged to enable the worker to work safely before commencing work, any change in the working system, the introduction of new work equipment and technology, and the change of workplace.

An employer may not allow self-employment to a worker who is not qualified to work safely. A worker who is not qualified to work safely must be under the direct supervision of a worker who is capable of working safely.

The employer is obliged to ensure that the places that are used at all times are safe, maintained, adapted to the work and the proper condition, in accordance with the rules on occupational safety.

RISK EVALUATION

Risk assessment is a procedure that determines the level of hazards, harmfulness and effort in terms of injuries at work, occupational diseases, work-related illnesses and work-related disorders that could cause harmful consequences for the safety and health of workers. A risk assessment should be made for each job as it is a fundamental document for the implementation of measures to protect the health and safety of workers.

The definitions used are as follows [4]:

- ≡ **Hazard:** The intrinsic property or ability of something (e.g. work materials, equipment, work methods and practices) with the potential to cause harm.
- ≡ **Risik:** The likelihood that the potential for harm will be attained under the conditions of use and/or exposure, and the possible extent of the harm.
- ≡ **Risik assessment:** The process of evaluating the risk to the health and safety of workers while at work arising from the circumstances of a hazard at the workplace.

During the risk assessment of CNC machines it is necessary [4]:

- ≡ Identify all dangers and hazardous situations that may occur when working on a CNC machines,
- ≡ Identify all persons who may be exposed to perceived hazards,
- ≡ Identify the type and weight of possible health damage and the frequency of exposure,
- ≡ Risk assessment - explore the possibility of removing or reducing the risk level,
- ≡ Determine priority procedures and decide on removal or reduction measures risk,
- ≡ Document risk assessment.

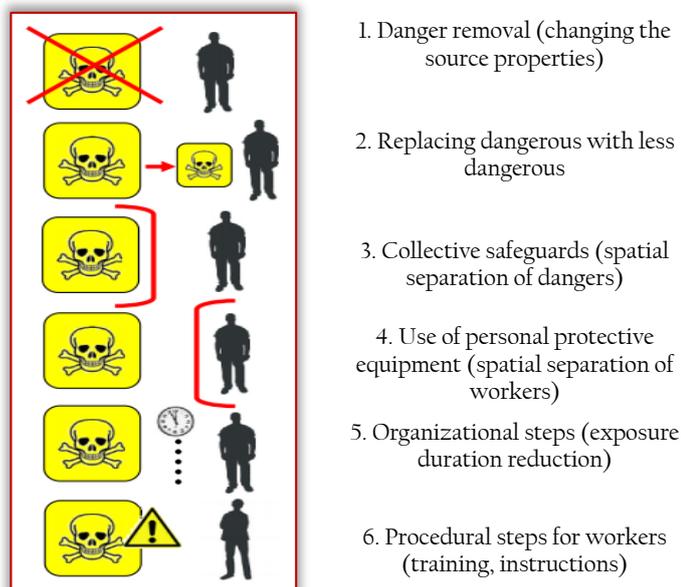
The risk assessment shall be kept in writing and in electronic form and shall be available to the worker at the workplace. The risk assessment can be prepared by the employer or made by the authorized person. The person who creates it (the employer or the authorized person) and the workers or their representative (employee commissioner) are involved in the design.

Follow the five steps in this leaflet [5]:

- Step 1- Identify the hazards
- Step 2- Decide who might be harmed and how

- Step 3- Evaluate the risks and decide on precautions
 - Step 4- Record your findings and implement them
 - Step 5- Review your assessment and update if necessary
- When deciding on measures to reduce risk at work it is necessary to apply measures of importance (Table 2), as follows [6]:

Table 2. Measures to reduce risk by importance



1. Danger removal (changing the source properties)
2. Replacing dangerous with less dangerous
3. Collective safeguards (spatial separation of dangers)
4. Use of personal protective equipment (spatial separation of workers)
5. Organizational steps (exposure duration reduction)
6. Procedural steps for workers (training, instructions)

Don't overcomplicate the process. In many organisations, the risks are well known and the necessary control measures are easy to apply. You probably already know whether, for example, you have employees who move with heavy loads and so could harm their backs, or where people are most likely to slip or trip. If so, check that you have taken reasonable precautions to avoid injury.

If you run a small organisation and you are confident you understand what's involved, you can do the assessment yourself. You don't have to be a health and safety expert.

If you work in a larger organisation, you could ask a health and safety advisor to help you. If you are not confident, get help from someone who is competent. In all cases, you should make sure that you involve your staff or their representatives in the process. They will have useful information about how the work is done that will make your assessment of the risk more thorough and effective. But remember, you are responsible for seeing that the assessment is carried out properly.

When thinking about your risk assessment, remember:

- ≡ a hazard is anything that may cause harm, such as chemicals, electricity, working from ladders, an open drawer etc;
- ≡ the risk is the chance, high or low, that somebody could be harmed by these and other hazards, together with an indication of how serious the harm could be.

CONCLUSION

Today's modern industry is unthinkable without CNC machines. The application of CNC machines is wide. Its application lies in wood industry, furniture industry, ship and automotive industry, used to manufacture various

machine parts (shafts, shafts, various profiles, flanges), bending for pipes, laser and plasma cutting, and even the toy industry. From the above, it can be concluded that these are machines of very great potential.

The origin of the hazard is in the means of work (machinery and equipment for work and work space), and the harmful consequence can be due to the error on them or because the basic occupational safety rules are not applied at all or not satisfactorily, or because of the incorrect procedure of the worker.

Economic losses, either directly or indirectly, have a large economic burden that negatively reflects on national income. Injuries due to mechanical hazards can be of a different nature, from light bruises as a result of bumps, surface injuries and bumps to severe and lethal injuries. Various protective devices that prevent touching or approaching hazardous places are used to protect against mechanical hazards. In addition, parts of machines, objects or particles that can fly out of the machine (release of parts, particles of processing objects, etc.) are also present.

There are many different ways to protect against machine-related hazards, such as CNC machines, and other complex systems. One way is to install a technical protective device on the machine itself, such as an automatic stop device when the machine is stopped away if the machine is improperly operated or the worker is injured. In addition to protective technical devices, there are also personal protective equipment that must be used by the workers on the machines according to the Occupational Safety Act.

When working with CNC machines the required personal protective equipment is eyes, work clothings, shoes with steel caps and protective gloves.

This paper is intended to encourage employers, workers, and all those who have contact with machines, devices, appliances to cautiously and responsibly behave when using them to protect themselves and others and transfer knowledge around them.

Note: This paper is based on the paper presented at DEMI 2019 – The 14th International Conference on Accomplishments in Mechanical and Industrial Engineering, organized in Banja Luka, BOSNIA & HERZEGOVINA, 24–25 May 2019.

References

- [1] Pavlović M., Učur M. Đ., (2009). *Zaštita na radu – provedbeni propisi s komentarima i tumačenjima*, Zagreb, , ISBN 978-953-7177-28-7
- [2] Trbojević, N., (2016). *Zaštitni uređaji na strojevima*, Zavod za istraživanje i razvoj sigurnosti, Veleučilište u Karlovcu, Zagreb, ISBN 978-953-7343-76-7.
- [3] Mijović B. (2012). *Zaštita strojeva i uređaja*, Veleučilište u Karlovcu, Karlovac, ISBN 978-953-7343-60-6.
- [4] Office for Official Publications of the European Communitiets, (1996). *Principles and general practice of risk assessment at work*, ISBN 92-827-4278-4.
- [5] Health and Safety Executive, (2011). *Five steps to risk assessment*, INDG 63(rev3), London, ISBN 978 0 7176 6440 5.
- [6] Hrvatski zavod za zaštitu zdravlja i sigurnost na radu (2011). *Praktična smjernica za procjenu rizika na radu*, Hrvatski zavod za zdravstveno osiguranje, Zagreb.