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SAFETY AT WORK WHEN WORKING WITH THE MACHINE FOR LASER METAL CUTTING

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Abstract: Modern manufacturing often requires extreme precision on extremely tough materials. Although laser cutting machines have brought certain improvements in terms of quality and productivity, at the same time, certain dangers and harms have emerged when using them. All potential dangers and hazards related to using the machine are listed in this paper. By applying the Kinney method, a risk assessment was carried out for the workplace of an operator who handles a laser cutting machine.

Keywords: *Laser cutting machine, Risk assessment, Material, Safety*

INTRODUCTION

Laser cutting is a technologically advanced method of metal processing that uses concentrated light energy to perform cutting. The process of laser cutting metal itself enables high precision, speed, and flexibility in the metalworking industry. When cutting metal in the cutting zone, the metal melts, burns, or vaporizes (Powell, 2016), or excess material is removed with the help of compressed air, leaving a high-quality cut.

Although laser cutting machines have brought certain improvements in terms of quality and productivity, at the same time, certain dangers and harms have emerged when using them. In the paper (Palega, 2020), the identification of hazards when working as an operator of a laser cutting machine was carried out to assess the risks. The method used in this research included workplace observation (using a checklist), an interview with the employer, an interview with selected employees and a person in the position of a specialist for occupational safety and health, and an analysis of the company's internal documentation. The application of the Risk Score method, through which the risk assessment was conducted, showed that many different risk factors lead to accidents or illnesses for employees operating laser metal cutting machines. Since during metal cutting, harmful particles in the air in the form of smoke, dust, and aerosols appear, which pose a significant threat to the health of workers, the paper (Salem, 2023) presents a method for detecting harmful products using modern, new-generation techniques. The method itself represents a new material classification technique that uses a new deep

learning model architecture to classify materials being cut based on processing a large number of images during the cutting process itself. The proposed approach involves training a convolutional neural network (CNN) on a large set of graphical data during the cutting process to recognize different types of materials for safe and efficient cutting. The results obtained show that the proposed method achieves high accuracy in the categorization of materials, especially those that have increased emission of harmful particles during cutting. The microclimate and air quality in facilities where the cutting process is carried out are of great importance for the health of employees who are in the positions of cutting process operators. To reduce the level of air pollution in production facilities, technical solutions such as the installation of fume hoods and filtration systems are used. In the paper (Taranyuk, 2025), an analysis of the emission of harmful products was carried out, an assessment of the efficiency of the ventilation and filtration system for harmful gases generated during the cutting process was carried out, and calculation methods for determining the concentration of harmful substances were proposed.

TYPES OF METAL LASER CUTTING MACHINES

According to the design, there are two types of laser metal cutting machines: Open-type laser metal cutting machine (Fig. 1-a) and closed-type machine (Fig. 1-b). The components of these machines are the same, with the only difference being the construction of the machines themselves. In the closed-type machine, there is a housing (capsule) that completely encloses the working space of the machine. Therefore, the machine is significantly safer compared to the open-type machine, because the worker is protected from laser radiation, fumes, dust and waste that occur during the machine's operation (Fig. 1-a), and it allows the worker greater flexibility because it significantly reduces the use of personal protective equipment, which in some situations significantly complicates the work process (Fig. 1-b).

Figure 1. A representation of a worker working on a closed-type machine (a) and a worker working on an open-type machine (b)

POTENTIAL HAZARDS AND HARMFUL DAMAGES DURING THE OPERATION OF A LASER METAL CUTTING MACHINE

When using laser metal cutting machines, there may be potential hazards due to exposure to laser light, exposure to high temperatures that can cause fire, or the risk of inhaling toxic substances from the air. Proper machine setup, employee training, proper handling, and safety precautions must be implemented to ensure the safe use of a laser metal cutting machine.

Mechanical hazards

In addition to the dangers that may arise from radiation or the presence of chemicals, the operation of a laser cutting machine is also accompanied by mechanical dangers:

- Circular movement of the cutting head,
- Material splashing during cutting and kickback,
- Hazards related to high voltage,
- Handling sharp parts and edges of machines or materials,
- Fire hazard.

Physical hazards (radiation)

According to its operating principle, a laser metal cutting machine involves focusing and using a laser beam. The operating principle of a laser cutting machine involves focusing and using high-energy laser beams, and for this reason, radiation poses a great danger. Laser radiation is in the form of high-energy photons and has the following specific hazards:

– Risk of vision damage,
– Risk of skin burns,
– Other potential hazards related to the use of personal protective equipment.

Chemical hazards

During the cutting process, laser cutting machines often create certain chemical hazards, which include:

– Release of toxic gases,
– Hazardous dusts and fumes,
– Handling toxic materials,
– Cutting specific materials has the potential to produce laser-generated air pollutants.

Physical hazards (noise and vibration)

Noise hazard is one of the hazards that is often overlooked when working with laser cutting machines:

– Noise level,
– Psychosomatic illnesses.

In addition to the above dangers and harms, it is important to mention the harmful effects of the microclimate that occur due to elevated temperatures in the cutting zone, where skin burns and other health problems may occur due to the lack of use of PPE (Personal Protective Equipment).

PREVENTIVE MEASURES TAKEN TO ELIMINATE DANGERS AND HARMFULNESS

Machines for laser cutting of materials undoubtedly represent one of the most sophisticated tools for precise cutting and engraving of materials. However, as a result of improper handling, unplanned injuries may occur to persons who operate the mentioned machine, and for this reason, certain preventive measures must be taken, such as:

– Persons handling the machine (operators) must be familiar with the principle of the machine,
– Maintenance and inspection of the machine must be done regularly,
– The working environment around the machine must be controlled,
– Dispose of waste generated during the cutting process promptly,
– Use the machine manufacturer's instructions,
– Persons who operate the machine must be trained for safe work,
– Fire extinguishers must be arranged near the machine,
– Never leave the cutting machine running without the supervision of an employee,
– It is necessary to know which materials and thicknesses can be safely cut on the machine.

RISK ASSESSMENT FOR WORKING WITH A METAL LASER CUTTING MACHINE

According to the definition, risk represents the probability of injury, illness, or damage to an employee's health due to hazards and harm in the workplace. According to the Law on Safety and Health at Work ("Official Gazette of RS", No. 35/2023), risk assessment is the systematic recording and assessment of all factors in the work process that can cause occupational injuries, illnesses or health damage and determining the possibilities, i.e. the way to prevent, eliminate or reduce risks at the workplace and in the working environment.

Risk assessment using a 5×5 matrix

One of the methods that can be used to assess and manage OH&S risks is the Kinney method. In the Kinney method, risk fulfillment is viewed as the occurrence of danger and harm (Risk Assessment Manual, 2010). Therefore, by identifying potential hazards and harms, potential risks to work safety are determined.

Table 1 shows the risk assessment using the 5x5 matrix (Kinney method) for working with a laser metal cutting machine.

Table 1. Risk Assessment

No.	Code	Identified Hazards	S	E	P	Level of Risk	Preventive Measures
1	02	Free movement of materials that can cause injury to the employee (the material may be splashed during the cutting process).	3	2	6	MEDIUM RISK	Installing a protective barrier that prevents material from splashing. Use personal protective equipment, such as safety glasses to avoid eye injuries, or a protective mask that protects the worker's face.
2	07	Hazardous surfaces that the employee comes into contact with, which have sharp edges and corners, spikes, rough surfaces, protrusions, etc. (injury may occur due to handling processed material that has sharp edges).	4	2	8	MEDIUM RISK	After laser cutting, the material must be further processed by grinding. Workers must be trained in how to handle materials properly. Using personal protective equipment. Training workers in providing first aid in case of injury;
3	15	Danger from direct contact with live parts of electrical installations and equipment	2	3	6	MEDIUM RISK	Before any maintenance, repair, or cleaning of the machine, it is mandatory to

		(contact with high-voltage electrical systems may occur due to improper use or maintenance).					turn off the power to the machine and ensure that it is completely disconnected from the power source - LOTO procedure. Regular maintenance of the machine's electrical installations. Installation of protective barriers around high-voltage components and posting warning signs.
4	24	High temperature (during the working process, the machine emits high temperatures that can adversely affect the health of employees, causing e.g. burns)	2	3	6	MEDIUM RISK	Installation of cooling systems; It is important to organize periodic breaks and allow workers exposed to high temperatures to rest in cooler parts of the workplace. Work areas where there is a risk of high temperatures should be marked with safety signs warning of the danger of burns.
5	26	Laser radiation (laser rays can cause eye damage, such as retinal burns).	2	3	6	MEDIUM RISK	Place signs indicating the presence of high-power lasers, which should be prominently displayed in visible locations. It is best to use closed-type machines to prevent the laser beam from scattering in the work area. Wear protective glasses that have filters specific to the class of laser.

CONCLUSIONS

To ensure safe working conditions with a laser metal cutting machine, the operator must be trained to work with the machine itself. Workers should be familiar with the technical description of the machine, how to operate it, the materials being cut, and the safety measures taken to prevent injuries to workers. It is also important to carry out regular inspections and maintenance of the machine. Maintaining the work area is also of great importance, as is the placement of various signs indicating potential hazards. The use of personal protective equipment greatly contributes to reducing the occurrence of hazards and harm in the workplace

of the operator of the laser material cutting machine.

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