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EFFECT OF CUTTING LIQUIDS AND OILS IN MACHINING PROCESS ON ENVIRONMENTAL

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Abstract

Sustainability is an urgent social development task that is increasingly coming into the limelight. The United Nation's Brundtland Commission Report of 1987 concluded that humanity could make development sustainable if it meets "the needs of the present without compromising the ability of future generations to meet their own needs." Industrial companies' implementation of the environmental management system on a voluntary basis and by implementing them undertake to carry out all their activities in an environmentally friendly manner. The aim of this contribution is to focus on the issue of the impact of the metalworking industry, specifically chip machining, on the environment. Based on the analysis of the proposed register of environmental aspects according to the requirements of ISO 14001, we focus on the aspects that threaten the environment the most and try to minimize their impact. In this case, it is specifically the cutting fluids used in machining. The effort is to prepare the basis for the preparation for the certification of the company according to ISO 14001 and mainly to propose corrective measures to minimize the impact on the environment.

Keywords: Environment; sustainable development; metalworking industry; cutting liquids; machining.

1. Introduction

Use Society changes over the years and with it the view of certain problems that previous generations did not solve as a priority. If we talk about the natural environment, man himself was an integral part of it at the beginning of human evolution. Among the reasons why it was so, in the first place is the effort to stay alive, which was later replaced by the fulfillment of human needs, which, however, resulted in the fact that man began to disturb nature with his artificial environment. Underneath all the above (i.e., natural environment, artificial environment, and socio-economic conditions) it is possible to imagine an interwoven system which is referred to as the environment or environment [1]. According to the ISO 14 001 standard, the environment is defined as the company's environment, including air, water, soil, natural resources, plants, animals, people, and the relationships between them. Because of this, the environment cannot be talked about as a business problem, but rather as a global system problem. The aim of this contribution is to focus on the issue of the impact of the metalworking industry, specifically chip machining, on the environment. Based on the analysis of the proposed register of Environmental Aspects (EA) according to the requirements of ISO 14001, we focus on the aspects that threaten the environment the most and try to minimize their impact.

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1.1. Chip machining and the environment

In the introduction, it was mentioned that the environment is an issue that does not only concern the corporate sphere but is a global sphere. This is not the case in the machining environment either. The machining process itself also includes flows of energy and resources that are necessary for the given production. Other aspects influencing the impact of the machining process on the environment also include the factory itself or the company building with the heating, ventilation, and air conditioning system, and even the supply and customer chain [2].

It is necessary to evaluate all the environmental impact of chip machining and to know the exact production process of a certain product, because the environmental impacts can also differ from product to product, for example because other production methods or other operational means can be used [1].

1.2. Legislative requirements for environmental conformity assessment

EMS systems are currently the most suitable evidence for organizations to prove that they carry out their activities with respect to the environment and that the production or service itself is designed so that the environmental impact is as small as possible, ideally zero.

In this contribution, we focus on designing an environmental management system according to the ISO 14 001 standard, as it is one of the most widespread methods in the Czech Republic. This standard serves as a tool that enables the company to ensure the fulfillment of the declared ecological concept and at the same time to demonstrate this fulfillment. At the same time, however, this is not a one-time issue, but rather a spiral development. The very concept of this system is such that it can be applied to any organization, and it does not matter what activity the organization performs [1], [3], [4], [5].

1.3. Register of environmental aspects according to ISO 14001

In today's unstable and complex environment, there are many aspects that a manager must focus on, and it goes without saying that individual problems cannot be approached equally. How to approach these issues is shown directly in the ISO 14 001 standard. The standard therefore requires an organization to create and follow a procedure for identifying the environmental aspects of its activities, services, and products. The result is the aspects that the organization can directly control or have some influence on, but the most important thing is to determine those aspects that have or can have a significant impact on the environment.

According to the standard, all aspects of the company's activities affecting the environment were mapped. This was followed by their evaluation and determination of essential aspects. How to carry out this evaluation is again not directly determined by the standard and it is only up to the company itself which criteria and procedures it chooses. The criteria listed in the following table 1 were chosen for this work. However, the very evaluation of the significance of individual environmental aspects [1] is crucial for this contribution.

Assessment:

$$\text{Frequency} \cdot \text{Severity} \cdot \text{Crash} \cdot \text{Cost} = \text{Significance of EA} \tag{1}$$

Significance of EA:

Aspect type	Point range
Common aspect	1 - 50
Significant aspect	51 - 150
Alarming significant aspect	150 - 300

Table 1. Criteria for evaluating environmental aspects

There is no need to implement any corrective measures for common aspects. Significant aspects need to be further addressed and appropriate corrective measures should be implemented to reduce their significance.

Register of environmental aspects														
Machining hall														
Process	Impact					Assessment						Significance of aspects	Control measures	Monitoring
Environmental aspect	Water	Soil	Air	Resources	Man	Frequency	Severity	Accident	Costs	Legislation	Evaluation			
Process of the Production														
Generation of general waste		•			•	4	2	2	1	A	16	Common	Training	Continuous monitoring
Generation of hazardous waste	•	•	•		•	3	3	3	1	A	27	Common	Training	Continuous monitoring
Consumption of metallurgical material		•		•		4	2	1	1	N	8	Common	Training	Production records
Generation of waste from metallurgical material	•	•	•		•	4	3	3	2	A	72	Significant	Training	Production records
Use of cutting oil during machining	•	•	•	•		4	3	3	2	A	72	Significant	Training	Production records
Generation of waste oil	•	•	•		•	4	3	4	2	A	96	Significant	Training	Production records
Use of chemical substances			•	•	•	2	3	3	1	A	18	Common	Training	Continuous monitoring
Formation of inhomogeneous dust emission during grinding			•		•	4	3	1	1	A	12	Common	Training	Continuous monitoring
Noise generation	•	•	•		•	4	2	1	1	N	8	Common	Training	Continuous monitoring

Table 2. Register of environmental aspects for the machining hall

In the case of alarmingly significant aspects, immediate action is needed because they are so serious that ignoring them could mean irreversible consequences in the field of the environment. For the proposed register, the impact is related to the group of water, soil, air, resources, and people. In practice, the assessment takes place in a work team of people who work together to implement the EMS in the company.

2. Cutting fluids and their impact on the environment

Based on a detailed analysis of possible impacts, we decided to respond to the alarming possible impact of cutting fluids on the environment. Process fluids are an indispensable part of chip machining. In order to achieve the best results, the correct cutting fluid must be selected. There are two types of process fluids for metalworking. We divide them according to their water content into:

- water-miscible cutting fluids
- cutting oils

We can also use molten metals as cutting fluids, such as tin, bismuth, zinc, etc. These are used when machining hard-to-machine metals. Process fluids have two main effects, cooling and lubrication. Water-miscible cutting fluids have a cooling effect, while cutting oils have a lubricating effect. Therefore, it must always be considered for what purpose we need to use the given liquid [6], [7], [8].

2.1 Ecological aspects in the use of cutting fluids

Nowadays, environmental issues are increasingly being addressed. Due to global warming and the profiteering of non-ecological farming of the past years, more and more emphasis is being placed on the greening of industry. Current legislation has more and more stringent requirements, which is why even process fluids are increasingly controlled. The main controlled component is the disposal of process fluids and their handling. Each company must sign contracts during liquidation, which are subsequently controlled by the state, to prevent the discharge of process fluids into nature, as has already happened several times in the past. Transportation and storage play an equally important role here. Everything must be done with great care to avoid an accident that could contaminate nature and contaminate groundwater. Water is a very important component in the field of cutting fluids. Each business should consider the machining method and the cutting fluid used. To give you an idea, only 50 l of oil is enough to cover 1 km2 of water surface with a continuous layer with a thickness of approximately 0.05 μm. This causes a decrease in biodegradability, which means that the self-purification process of water takes place very slowly, and this can cause the extinction of aquatic organisms. Unfortunately, due to the use of process fluids, polydisperse aerosols are released, which contaminate the working atmosphere and thereby harm health [6].

2.2 The effect of cooling emulsion on the environment

In recent years, our planet has been affected by a major drought. Therefore, water consumption should be reduced. Thanks to the cancellation of machining using a cooling emulsion, 3 862,7 liters of water would be saved annually (on one CNC machine), which would provide water for 1 person for 3 and a half years.

Furthermore, the reduction of water consumption would improve the health of the employees, as there would be no skin contact with the cooling emulsion, which is often a significant source of allergic reactions and various eczemas. It is a hazard class 2, which means that it must not enter the water, as there would be a large contamination and pollution that could be fatal for organisms, especially when the water is contaminated, the destruction of aquatic organisms is a certainty. Since water makes up 95% of the emulsion, there is more evaporation, which is unfavourable for the human body, which can develop respiratory diseases when inhaling the vapours. Therefore, emphasis must be placed on high-quality vapor extraction and air purification [6].

2.3 The impact of cutting oil on the environment

Cutting oil greatly endangers the environment if disposed of improperly. It is enough for only a small amount to encounter water and there is already a big threat. Cutting oil is destructive to aquatic organisms, the water hazard level is 2. The same aspects apply to it as for cooling emulsion, only because of its 100%, it is treated with more respect than cooling emulsion. Its stability is higher, it does not undergo rapid degradation. May cause an allergic reaction if it encounters the skin. Therefore, it should be handled with gloves. The manipulator should wear long sleeves, long pants, and safety glasses. If the oil splashes into the eyes, it causes serious health problems. When using CNC machines, the risk of contact with cutting oil is significantly lower than with conventional machines. It must be dealt with according to legislation. Violations of decrees and regulations can often be dealt with by sanctions [6], [7], [8].

2.4 The effect of biodegradable oil on the environment

Biodegradable oil affects the environment only with some chemical additives. These serve to ensure that the given oil has the same properties as mineral cutting oil. No problem is expected here in case of contamination with human skin, the oil is considered suitable for work according to the legislation. As far as the environment is concerned, the consequences of contamination are not fatal, as it is an oil based on sunflower oil, which is fully biodegradable. However, it must not be poured into the sewer, etc. It can also be treated as a food product if it is filtered, and no chips of the processed material remain in it. However, it must be checked more often to prevent its degradation [6], [7], [8].

3. Proposal of corrective measures to reduce the impact on the environment

3.1 The problem with the release of dangerous substances in general

This environmental aspect refers to all hazardous substances (thinners, paints, oils), including natural gas. According to the register, it is known that such a leak can occur both in the warehouse and in the production hall.

Measures that a business can put in place include:

- At the workplace where these dangerous substances will be present, a list of these substances and their corresponding safety data sheets will be maintained, which include H-phrases (standard phrases about the danger of chemical substances and mixtures) and P-phrases (standardized instructions for safe handling of chemical substances and their mixtures).
- Hazardous substances will be stored in designated places that will not be accessible to unauthorized persons. Storage places must always meet the requirements for the given substance and all these places must be marked with warning symbols that are related to the stored substance (see Fig. 1).

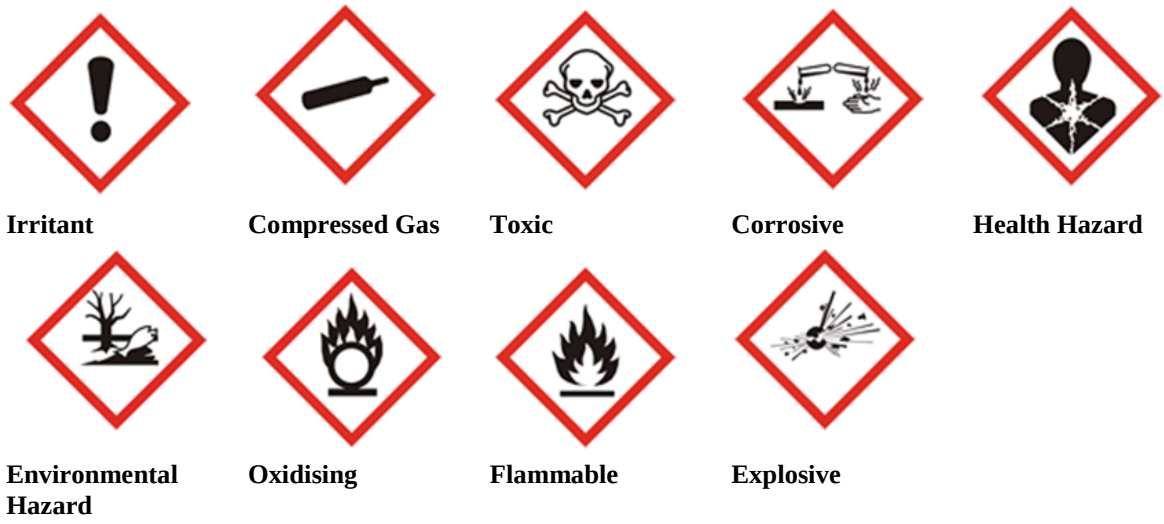

Fig. 1. Warning symbols according to ES 1272/2008 [9]

- A responsible person will be designated in the company who will oversee the emergency kit intended for oil products.
- The company will develop controlled documentation dealing with leakage, pollution, and subsequent disposal of oil products.
- Hazardous substances will be stored using catch basins/collection tubs, which in case of leakage will prevent contamination of soil and waterways (see Fig. 2).

Fig. 2. Catch basins/Collection tubs [10]

- All equipment that distributes or burns natural gas will be regularly inspected and adequately vented to prevent the accumulation of gas that could result in an explosion.

3.2 Use of cutting oil during machining

Corrective measures for this aspect will be like those in the chapter on the release of hazardous substances.

3.3 Generation of waste oil

Waste oil is classified as hazardous waste. It is a waste that is produced from cutting oils during the machining process. Measures that a business can put in place include:

- To achieve maximum use of the oil, the metal shavings will be separated from the oil after use, using a centrifugal device (centrifuge) and filters (see Fig. 18). The result will be oil that will be reused. This process cannot be carried out indefinitely, because even with fine filtration, a small amount of microscopic metal particles will remain in the oil. This will cause a change in the original properties, which will result in a deterioration of the cutting oil's function, and it will be necessary to replace the oil after several uses.
- The company will start using suitable oil substitutes that will have less impact on the environment.

Fig. 3. Centrifuge with manual drum change [11]

3.4 Disposal

The disposal of cutting emulsions or cutting oils is carried out with the help of specialized companies. Larger machining companies can arrange their own disposal facilities, but this involves several strict and complex hygiene processes and controls that are not easy to pass. Because of this, the first option is chosen in most companies. To give an idea, about 26,000 tons are consumed annually (according to a survey by Fuchs oil). Most of them end up in demulsification stations, where the water is separated from the oil. The water goes to the WWTP (wastewater treatment plant) and the oil is mostly burned in incinerators.

4. Conclusion

There According to the created register, environmental goals were chosen for the identified significant aspects, for which possible corrective measures were also written down, which could help to reduce their significance. In this post, we focused mainly on cutting fluids and their impact on the environment. Cutting fluids must be handled in accordance with legislation and relevant decrees. They must be disposed of by specialized companies to prevent natural disasters. Workers should be sufficiently trained so that they do not knowingly contaminate cutting fluids and do not neglect their care. This should be monitored more, as the workers do not care much about quality. From an economic point of view, the cooling emulsion is the most advantageous, because water makes up more than 90% of the volume.

However, in terms of price, it is approached by biodegradable cutting oil, where disposal costs fall. Businesses should also consider machining with petroleum cutting oil, which can last for several years with proper care, again reducing costs. An important aspect to consider is dry machining or machining with a low amount of cutting fluid. However, the tools must be adapted to handle other operational requirements. Another aspect that needs to be analysed in detail is the generation of waste from metallurgical material. This aspect was chosen as important mainly because it is not directly known what metallurgical materials will be machined. It is considered that metallurgical materials can also contain dangerous substances such as lead, nickel or phosphorus. So far, a corrective measure has been proposed in the form of limiting the use of these materials.

However, this cannot always be ensured, because the processing of a certain material can be crucial for a given enterprise and it is impossible to limit its processing. For the possible prevention and reduction of the environmental impact of this aspect will be subjected to future investigation.

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