Environmental management in automated systems for engineering production

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Abstract. The article describes the issues of environmental management and environmental savings. The goal of environmental management is to conserve and save raw materials, materials, energy resources, and to improve the environmental situation. This article describes the technical aspects of environmental management in mechanical engineering production. Identification of environmental aspects occurs on the basis of the process approach. To manage aspects of environmental management in engineering production an automated program “Coating Mode Solver” has been developed. The program interface is described. Automated program selects the optimal technical modes of the process. Optimal process modes allow managing environmental aspects, reducing resource consumption and having a positive impact on the green economy.

1. Introduction

Successful actions to protect the environment and conserve natural resources constitute environmental management. More formally, environmental management allocates or develops resources; uses, restores, rehabilitates, controls or assesses resources [1].

Environmental management includes solutions, strategies, programs and projects [2].

Environmental management is an administrative function that develops, implements and controls the environmental policy of an enterprise. This can be viewed as an integrated mechanism that realizes the main goals of sustainable development [3].

Environmental management is broad in scope and includes all technical, economic and other aspects of the environment [4].

The main task of environmental management is to reduce the risk of environmental damage [5]. Globalization places high demands on resource management, therefore it is necessary to accelerate the development of management in order to improve efficiency and competitiveness [6].

As scientific and technological progress develops, the level of organization of the production process is improved, the processing of raw materials and materials is improved, incentives for saving material resources are introduced and the amount of waste per unit of production decreases [7]. A great influence on the amount of waste has a rationing of the consumption of material resources, that is, a scientifically based determination of the planned measure of production consumption of raw materials, materials, fuel and energy.

This process includes [8]:
the study of factors affecting the development of norms of consumption of material resources for newly manufactured products or the implementation of a certain amount of work;
- adjustment and revision of current regulations;
- consideration and approval of new standards in the prescribed manner and their direct communication to work places.

At the same time, the tasks of using waste should be solved at the stage of the technological process development in manufacturing new products and the establishment of norms of material resources.

2. Methods and Prequisites
In engineering production, the technical aspects of environmental management are:
- prevention of accidental impacts on the environment;
- saving raw materials, the use of small energy resources;
- greater use of secondary resources;
- reducing waste, improving the quality of products for the environment;
- processing and use of waste in the production and consumption;
- reduction of situational risks with increased environmental and financial results in case of accidental impacts on the environment;
- reducing environmental risk for staff;
- improving the efficiency of industrial environmental monitoring and environmental monitoring of production processes (including monitoring the conservation and use of resources, sources of maximum release of pollutants into water bodies.

The environmental aspect is any element of production in an enterprise that is associated with environmental impact. The organization is required to identify controlled environmental aspects, it is assumed the possibility of further impact on them, in order to change [9]. Through environmental aspects determine the elements of the industrial activity of the enterprise, which have a negative impact on the environment and human health.

We use a process approach to the enterprise’s activities in identifying environmental aspects (Figure 1).

**Figure 1.** Process approach to the activities of the enterprise in the identification of environmental aspects.
Using the example of manufacturing rods of hydraulic racks for mechanized roof supports produced at LLP "KarGorMash-M", we will highlight aspects of environmental management that affect the ecological environment and human health (Table 1).

Table 1. Dependence of the sphericity coefficient of lead inclusions and average sizes of bronze lead inclusions on the modifier concentration

| Environmental aspect                                      | Aspect value | Main sources          |
|-----------------------------------------------------------|--------------|-----------------------|
| The ability to spill waste lubricants, oils for roughing and finishing rods | 3 l/year     | Cutting machines work |
| Evaporation of chromic anhydride from electrolytic baths for plating surfaces rods | 0.08 t/year  | Electrolysis bath     |
| Noise during chrome plating                              | 80 dB        | Electrolysis bath     |
| Large power consumption                                  | 54 066 kW/year | Electrolysis bath     |
| Abrasive dust                                             | 2.7 t/year   | Cutting machines work |
| Metal dust                                                | 4.8 t/year   | Cutting machines work |

The management of environmental aspects in the production of rods for mechanized roof supports can be carried out through the use of computer-aided design of technological processes.

To reduce the impact of environmental aspects, it is proposed to optimize the technological process for the production of mechanized supports rods. Optimization is to eliminate roughing and finishing of the rod manufacture, as well as replacing the process of chromium plating on the electric arc spraying.

Electric arc spraying is a resource-saving technology in the production of mechanized supports rods. In addition to changing the production process, the computer program “Coating Mode Solver” was developed, which is intended for automated calculation of technological parameters for applying protective coatings on the surfaces of engineering objects - mechanized supports rods.

3. Results and Discussion

One of the ways out of the current situation is automation of technological preparation of production and, in particular, development and application of computer-aided design systems for production processes. Today there is a rather large number of such systems from various developers. The main disadvantage of such automated systems is that it is necessary to analyze and adjust results of designing of production processes according to a specific current situation at the place of production.

The current situation is considerably connected with the fact that in the theory and methodology of process design there is a big number of recommendations on application of this or that technology solution which cannot be formalized and is applied only to specific cases. The vast majority of the existing CADs are constructed at best on the use of prototype solutions, and often the production engineers makes decisions themselves, based on the personal experience or experience developed by manufacturer. Formalization of process of designing and technology, which will be a basis of the system of design automation, will give a chance of production process design for various products, including new, not produced before. Thus, the creation of automation system of technological preparation of production integrating various on nature and content tasks of machine-building technology is an urgent task.

CodeGear RAD Studio Delphi 2009 was chosen as the development environment. It is a very powerful and convenient tool for developing applications for computers running the Windows operating system [10].

The development environment has a set of components and modules necessary for designing the external design of the forms, as well as the interface of the modules containing the source code, and
corresponds to the ideology of object-oriented programming. The development environment contains a built-in code inspector, which improves the performance of the application development process.

Hardware:
- processor - at least Intel Pentium I 100 MHz;
- the amount of RAM - at least 256 MB;
- the amount of free hard disk space - at least 3 MB;
- availability of a backup or uninterrupted power supply.

Technical requirements:
- availability of an operating system at least Windows XP;
- screen area of at least 800x600 pixels;
- High Color palette at least 16 bits.

The choice of hardware was based on the minimum system requirements imposed by the selected software on the hardware.

When the “Coating Mode Solver.exe” file is launched (two mouse clicks), a program window appears on the screen (Figure 2), in which it is necessary to enter the parameters of the product being processed and select the material of the sprayed coating.

![Coating Mode Solver program interface](image)

**Figure 2.** “Coating Mode Solver” program interface.

The proposed list of coating materials is not transferable, since foreign analogues of these materials have different mechanical and physical properties. Therefore, marking with foreign brands of steels is not provided as a translation. However, if it is necessary, these foreign steel grades can be added for selection in the program.

After filling in the proposed form with the data required for the calculation, it is necessary to click “Calculate” button.

After calculating the technological parameters of the coating, the optimal values of these parameters are automatically selected, at which the most accurate value of the coating thickness is achieved. In this case, the deviation error from the required value of the coating thickness does not exceed 2%. Results of the decision exceeding the given size of an error are excluded from calculation.
The history of the calculation can be viewed on the “Solving” tab, which displays the initial data entered, the results not exceeding 2% deviation errors obtained at each iteration, as well as the optimal calculation results.

The data displayed on the “Solve” tab is a program report and can be saved on a hard disk or portable device. To do this, click "Save" button on the bottom panel of the program.

The program provides the ability to compare the obtained parameters for each calculation. To perform the comparison, it is necessary to click “Add” button after each satisfying result operator to add the results to the set.

After adding the obtained parameters to the set, it is necessary to change any technological or geometrical parameters, for example, the diameter of the burner nozzle or the speed of part rotation, and carry out a new calculation and add the results to the set again. After the results of several calculations are added to the set, it is necessary to press the “Graph” button.

After performing this action, a window will open with graphs of dependencies obtained during the calculation. To change the displayed dependency graph, we change the value in the dependency field by selecting the necessary one from the list.

In order to save the image of the displayed graph, it is necessary to click “Save” button and select the path to save. To reset all added values, click “Reset” button on the bottom panel of the main application window. To view the design scheme, we click "Scheme" button in the bottom panel of the application. This program is easy to use for any user with basic computer literacy knowledge.

Using the program “Coating Mode Solver” gives more detailed data, reduces the time for writing the technological process, than the values of the same parameters set for reference. This program allows calculating the technological parameters of the deposition process for cylindrical parts of various dimensions and selecting the desired material for spraying from the list.

Thus, this program “Coating Mode Solver” calculates the technological parameters taking into account the initial data, and on the basis of these calculations provides optimal solutions and graphical dependencies, which is an important factor in the design of the technological process and in determining the environmental impact on the environment and human health. The program is an effective tool for resource conservation in machine-building enterprises.

4. Conclusions
1) Aspects of environmental management in the production of hydraulic rod props of mechanized roof supports were identified.
2) The authors developed software “Coating Mode Solve” for computer, designed for automated calculation of technological modes of applying a protective coating on the surface of engineering objects.
3) The selection of optimal modes in the “Coating Mode Solve” program allows reducing energy consumption by 3 times.
4) Optimum regimes of applying protective coatings in the production of cylindrical parts eliminate such environmental aspects as abrasive dust, metal dust.

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