Protection of Natural Environment as a Fundamental Element of Modern Engineer' s Education

W³ adys³ aw Jod³ owski[1], Boles³ aw Karwat[1]
Janusz Kowal[2], Bogdan Sapiński[2]
[1]*Department of Machines for Technological and Environmental Protection*
e-mail: karwat@imir.agh.edu.pl
[2]*Department of Process Control*
Faculty of Mechanical Engineering and Robotics
e-mail' s: jkowal@uci.agh.edu.pl deep@uci.agh.edu.pl
The University of Mining and Metallurgy in Cracow – Poland

Abstract: Growing number and variety of man-manufactured goods result in consequent degradation of the natural environment. Product's life history and a question of how multidisciplinary specialists can reduce environmental pollution at particular product's life stages, have been discussed. Development of educational process directed towards solution of environmental problems, being implemented at the University of Mining and Metallurgy, was also discussed.

Keywords: environmental protection, environmental education.

Introduction

Growing population density (Fig.1) [1] and growing people's requirements, result in consequent growth of a number and variety of products. After political and economical changes in the Eastern Europe in the early nineteenth, particularly great demand for manufactured products dynamically developed in this region. As example, it can be illustrated by a dynamic growth of the amount of automobiles in Poland (Fig.2) [1]. In the last decade, this amount has doubled, growing from 5,26 million in the year 1990 to 10 million in the current year [1], [2].

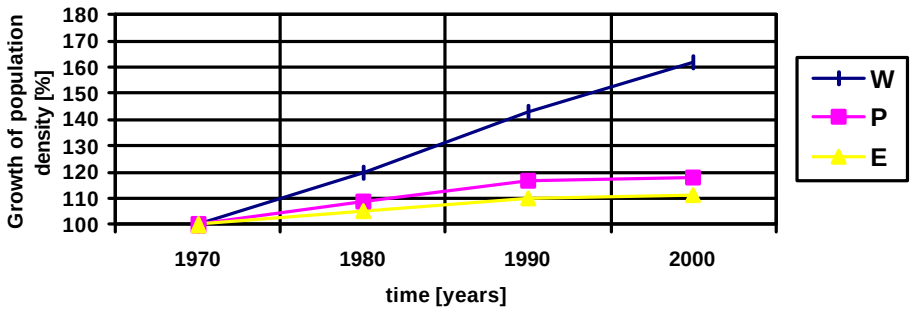

Fig.1 Growth of population density in the world (W), Europe (E) and Poland (P). State in the year 1970 = 100%

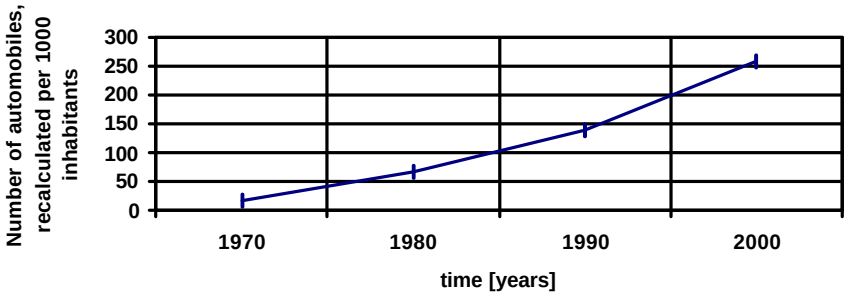

Fig.2 Number of automobiles in Poland, recalculated per 1000 inhabitants.

However, we can observe a serious conflict; the greater production the greater social satisfaction of goods possessed, but also the greater degradation of the natural environment. This degradation takes place during raw material mining, product manufacturing, product exploitation, and unfortunately, also during discharge of wastes to landfill. Like in other countries of the Middle and Eastern Europe, condition of the natural environment in Poland is very bad, particularly if compared with developed countries. Our arrears in this field have been disclosed only after political and economical changes in the early nineteenth, when it appeared that the situation in some districts is critical (catastrophic). Cracow, which is not only an industrial city but also a city of culture, science and national history, a city listed on the UNESCO list of world wide heritage of culture and nature, can be a good example of such critical situation. In this city, mean yearly standard of imission of sulphur oxide for areas of special nature value, was surpassed with 600-900% [3]. Similar situation comprised emissions of fluorine, nitrogen oxides and fine-grained suspended dust. This situation had of course harmful effect on health of local inhabitants, as well as on the condition of local monuments. Because of big scale of the problem and related costs, domestic situation in this field has been improving rather slowly. An example of average emission of sulphur oxides in the year 1995, i.e. in the middle of the transformation period in Poland, is shown in Figure 3. The data comprise Poland and two other countries of the Eastern block, and for comparison, three developed countries of Western Europe and USA [1].

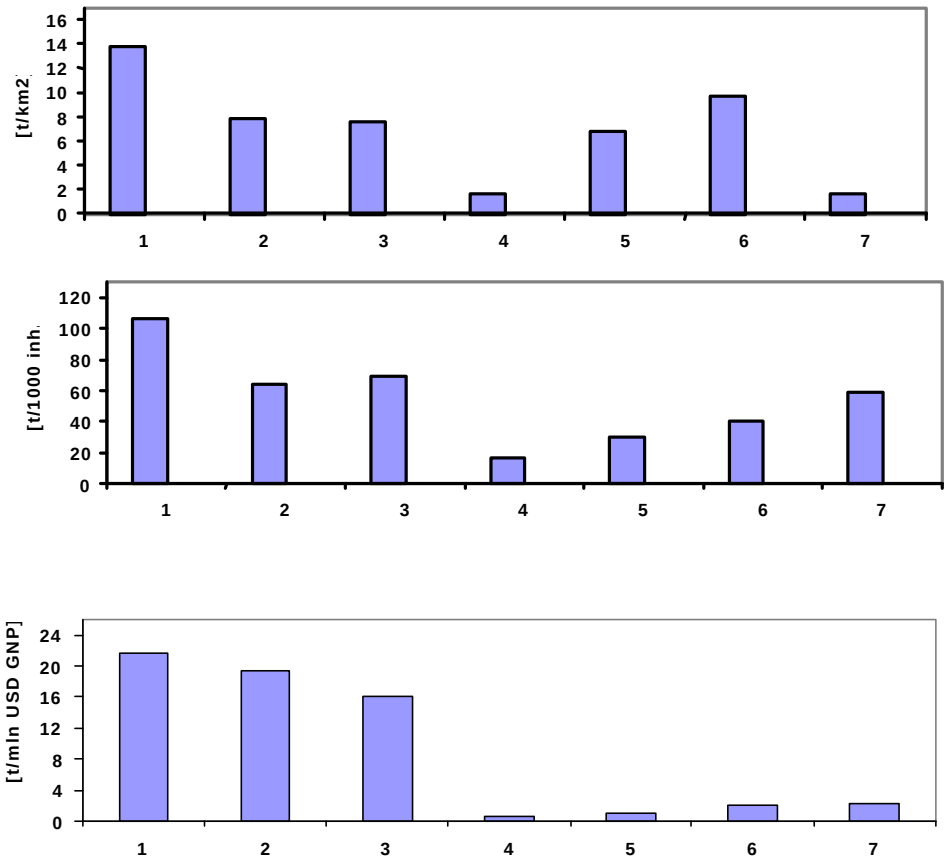

Fig.3 Emission of sulphur oxides in tones per km^2 (Fig.3.1), in tones per 1 thousand of inhabitants (Fig.3.2), and in tones per millions USD of gross national product (Fig.3.3); for : 1-Chech Republic, 2-Poland, 3-Hungary, 4-France, 5-Germany, 6-Great Britain and 7-USA. Data for 2,3 and 6 refer only to SO_2.

As seen from the presented data, the emission calculated per km^2 or/and per 1000 of inhabitants, is in the countries of our region a few dozens times higher than in the developed countries. However, if the emission calculated per million of USD of gross national product is concerned, i.e. a factor expressing the volume of produced pollutants, the results in our region are dozen times worse. The example presented above concerns only one gaseous (volatile)

pollutant. We could present many other examples related to polluted liquid wastes, polluted rivers and destroyed monuments, as well as to negative effect of degraded environment for the state of health of local inhabitants.

The other problem waiting to be solved is over 2 milliard (US billion) tons of industrial wastes polluting the natural environment [1], deposed in Poland in the last decades.

During last few decades, some new problems have came into being – the rapidly growing volume of used packaging, mostly non-returnable packaging. Only small amounts are sent for recycling process. In the world, for example, 55% of used aluminium cans are recovered, whereas in Sweden and Switzerland over 90%, and in Poland only about 5%. The other example: 70 – 80% of glass packages are recovered, whereas in Switzerland about 90%, and in Poland only 8% [4]. The rest is discharged to better or worse prepared waste disposal sites, enlarging areas of degraded environment.

The problem of degradation of the natural environment occurs during product manufacturing, during product's exploitation and also in the post-exploitation period. However, we can not consider this problem as an alternative, like made by some groups of "Greens", that : either possessing of material goods, i.e. production, or protection of the natural environment. We should consider, within reasonable scope, both these factors. Solving of such defined problem should be realised mostly by engineers. And not only those graduated from faculties of the environmental protection. The problem is so broad and complex that it should be solved by inter-disciplinary specialists.

1. POTENTIAL OF INTER-DISCIPLINARY SPECIALISTS TO INFLUENCE THE CONDITION OF THE NATURAL ENVIRONMENT.

1.1. Product life history.

In order to define which specialist can influence the condition of the natural environment, we should first analyse the life history of given product. Basic stages of the history are shown [5,6] in Figure 4. Design of the product made within designing sub-system (1) is sent to manufacturing sub-system (2). The product is usually manufactured of some half-finished products (elements). Both half-products and final products can be manufactured as a result of single or multiple production processes. During manufacturing of a half-product, and sometimes a final product, we use raw materials excavated within mining industry. Manufactured product is then sold, via distribution sub-system (3), to users (4) for farther exploitation. When the product is already used, it is sent to recycling sub-system (5), or it is deposed as a pollutant, in the natural environment. After suitable processing, the recycling sub-system sends the material derived from the used product (as a whole or in part) for secondary use in the manufacturing sub-system (2). Individual sub-systems (or the product itself) demand considerable supply of fuel and/or electrical energy, being a source of emissions of polluting agents.

1.2. Influence of a designer for the condition of the natural environment.

A designer, deciding about features and performance of potential product, has essential influence for the condition of the natural environment. There are the following features of a product, which may influence the natural environment [5] :

- product mass
- product durability
- product recycling potential

Mass of manufactured product can be decreased by :

- careful examination of loads acting on a given element, assemblage or construction, as well as examination of other working conditions;
- use of certified, high quality materials;
- use of suitable and precise calculation procedures.

The less mass of a product the less wear of material, i.e. the less production volume, and consequently the less environmental pollution. In some cases we are able to achieve also secondary effects :

- the less mass of manufactured product the lass consumption of energy carriers;
- the less mass of a product the less dimensions of designed plants, and consequently, the less space needed for installation of designed plant.

A designer has also essential influence on the duration of product exploitation. Selecting high quality materials in designing phase, or choosing materials with protective coatings, for example, metal sheets with plastic coatings, we can considerably elongate exploitation period of the product. Exploitation time can also be elongated by proper and

regular observing of maintenance, repair and overhaul procedures. Course and quality of these works depend, in considerable degree, on complexity of the manufacturing process. This consequently depends on options and solutions assumed by a designer. Elongation of product exploitation time results in decrease of average yearly material consumption, and consequently, in reduction of environmental pollution.

Someday, exploited products will be used-up, and if so, they should not be discharged to waste disposal sites, but they should be sent to recycling process. That is why, the problem of recycling should be taken into consideration already during designing stage.

The most important is :

- to select solutions enabling easy forward disassembling of the product;
- to limit variety of materials used, particularly plastics;
- to mark materials, which are already used.

Unfortunately, the recycling problem is practically not considered already in designing stage. We can observe small exception in automotive industry. A training centre for car designers respecting this concept has been developed in Lohhof near Munich in Germany.

In order to decide, which of designed products is the most ecological, a designer should define proper criteria. A concept of such criteria, enabling execution of a complex product estimation, already in a project phase, has been proposed in the present study [6]. This concept comprises three criteria based on the amount of gaseous, liquid and solid pollutants, which can be produced in all stages of the product history, including its manufacturing, exploitation and also a post-exploitation period.

1.3. Environmental protection in manufacturing process

Ecological activities and ventures, undertaken during manufacturing process, cab be realised mainly by process engineers and, so called, process operation services. The scope of these ventures will depend on labour organisation and competence assigned to individual persons. Process engineers will be responsible mostly for implementation of energy-saving and material-saving technologies. Less consumption of material and energy means less environmental pollution. In Poland, in the last decades, a great number of such modifications have been implemented in industry of steel metallurgy. Commonly used technology of continuous slab casting considerably reduced energy consumption, as well as, consumption of raw materials. In the current year, this technology will reach the level of 75% [7]. Implementation of ecological plants into the industry depends on : process engineers, maintenance services, designers, but first of all, on financial decision makers.

The other group comprises activities and ventures related to current production, i.e. observing technological regimes and careful control of production process. That will result in reduction of volume of defective products, and consequently, reduction of needless additional production, and finally, reduction of environmental pollution.

1.4. Environmental protection in product exploitation period

The products are transferred from manufacturing sub-system, via distribution sub-system, to a subsystem of product users. Distribution specialists have rather small influence on the condition of natural environment. They are responsible for proper transport and storage conditions, protecting the product against damage. This eliminates necessity of additional production, and consequently, further environmental degradation.

Two, partially parallel, groups of ecological activities can be realised in the user's sub-system. The first group comprises current exploitation of manufactured products, which should be executed in the most ecological manner. This is related mostly with motor driven products, such as industrial plants or automobiles. The less fuel consumption the less amount of combustion gases, and consequently, the less pollution generated by electric power stations.

Activities of the second group are aimed on the elongation of product exploitation period. Longer product exploitation periods resulting from proper planning, and then suitable observing of setting, maintenance and repair procedures, have considerable influence on the natural environment.

1.5. Recycling of used products.

In certain sense, all recycling sub-system procedures are pro-ecological. Obviously, also the other activities, mainly partial supply of raw materials to manufacturing sub-system, are realised at the same time. Recycling sub-system procedures comprise collecting of used products (or their fragments) and preparing of these materials for secondary use. Preparing (processing) procedure (different for various products) comprises : disintegration,

compression, and in case of complex products, also disassembling. Pro-ecological activities of specialists working in recycling sub-system will be directed toward such procedures, that maximal volume of used products is transferred into recycling process. This will comprise creation and development of waste collection points, as well as implementation of efficient recycling technologies. At the same time, the other activities should be undertaken, such as development of legal and financial regulations, enabling and even extorting recycling of used products, as well as, development of pro-ecological social education.

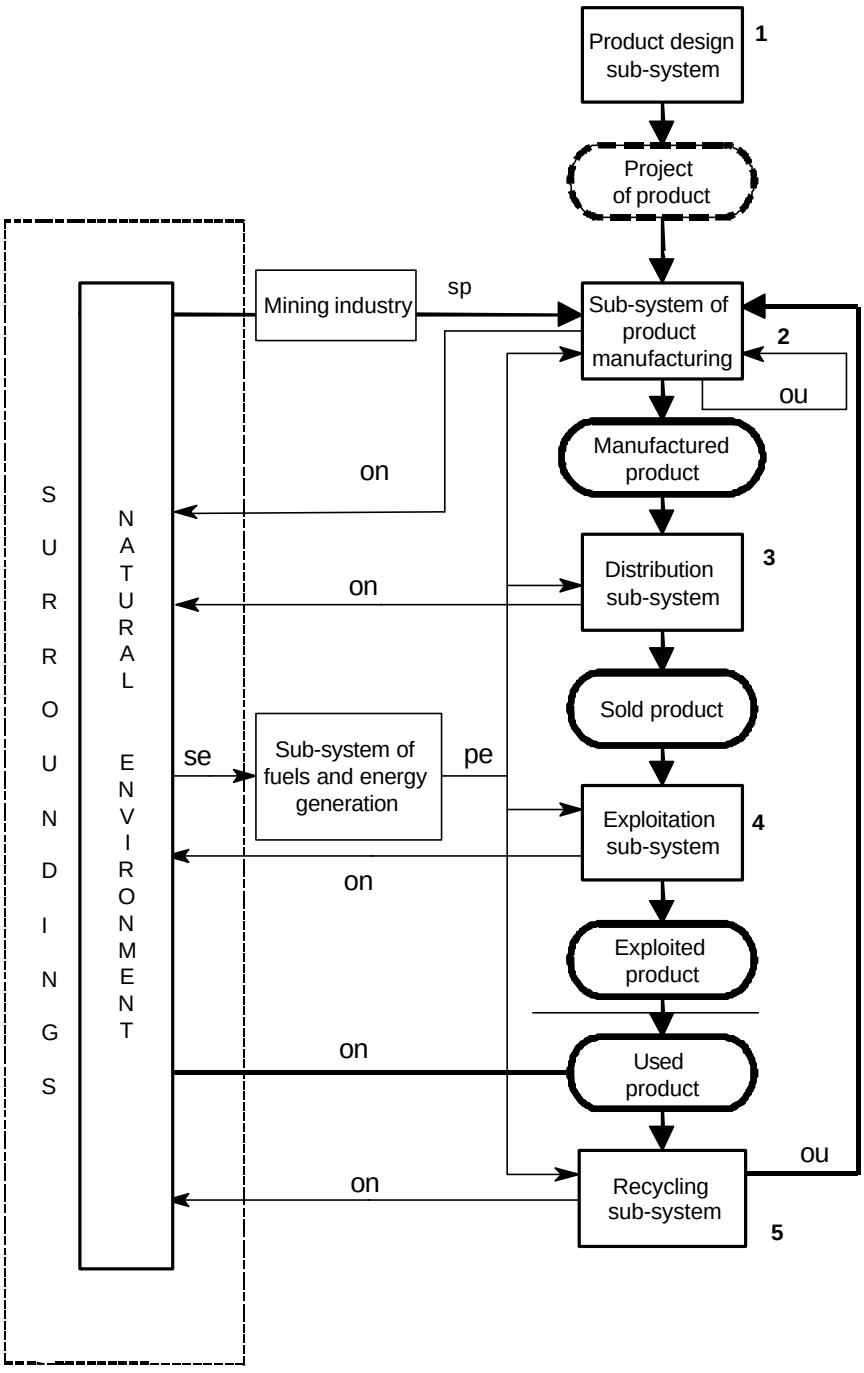

Fig.4 An outline of a product life history.
Individual streams are marked with the following symbols : sp – raw materials used in production process, se – energy raw materials, pe – fuels and electric energy, on – gaseous, liquid and solid wastes, ou – used products and recycled wastes.

1.6. Influence of other specialists on the condition of natural environment.

A problem of how the product design, maintenance and exploitation specialists can influence the decrease of degradation of natural environment, was discussed above. However, also the other specialists, related in some sense with product life history, are able to influence the environmental protection. At first we should mention specialists dealing with pollution reduction devices. Designing and implementation of efficient and cost-saving plants and devices enables their common use. That will obviously also help to decrease degree of environmental pollution. Considering the other groups influencing the condition of natural environment, we should also mention potential of engineers of automatics and management specialists. Engineers of automatics, by means of suitable designing and implementation of special control systems, can also effect the decrease of polluting emissions. It will be realised by suitable systems, assuring proper control of technological process itself, as well as, control of performance of the pollution reduction devices.

In the first group we may mention control systems, which :

- minimise consumption of energy during product manufacturing phase, for example, during pre-heating of a furnace before plastic working;
- ensure required composition of the product, as well as, proper dimensions of the worked element, what will eliminate, or at least decrease, volume of defective units;
- minimise periods of disturbances occurring, for example, during modification of composition of blast-furnace charge, or altering a type of manufactured product. Such unstable periods are usually accompanied by more intensive emission of pollutants.

The second group is aimed at such control of the pollution reduction devices, that their operational parameters could be tailored to changing operational conditions of technological plants.

The major task of management specialists is to ensure the company's profit and development. In this aspect, all activities directed toward the environmental protection, seam to be in contradiction with the major target task. However, it is not so obvious. We can undertake a number of activities aimed at the increase of the company's profit, being at the same time pro-ecological ones.

These are chosen examples :

- proper selecting of optimal supplying routes of industrial plants or sale points, reduces not only costs but also reduces fuel consumption, what is obviously profitable for the environment;
- use of electrofilters for dust removal from industrial gases, as well as, use of acoustic screens, may be a kind of cost-consumptive investment. However, it will improve labour comfort and health conditions of workers, what in global sense, may be profitable for the company.

2. ENVIRONMENTAL EDUCATION AT THE UNIVERSITY OF MINING AND METALLURGY.

The Stanis³aw Staszic University of Mining and Metallurgy is one of the largest Polish University level schools of engineering. It has about 25,000 students of various lines, being educated at 14 Faculties. Because this University deals with disciplines, which are not friendly for the natural environment, the environmental problems had been noticed a long time ago, being involved into the University's education process.

At the University of Mining and Metallurgy, the environmental education is actually realised on three different levels.

On the first level, only the broad outline of environmental protection problems is involved into the education program of major and special courses, particularly environmental problems related to technological processes. The scope of these problems is diversified, but it comprises at least general outline of environmental processes, with respect to the volume of polluting emissions and specification of devices used for environmental protection purposes.

The second level comprises more and more frequent creation of new courses, mostly facultative courses, which are totally related to environmental protection problems.

And the third level – comprises education of students on obligatory courses related totally, or almost totally, to the environmental protection problems. Subject matter of such education is usually related with the education profile of a given Faculty. A list of courses related with environmental problems, which are realised currently, or are planned to be implemented during oncoming academic year, is presented below [8] :

Faculty of Mining
- engineering works in environmental management
- waste and secondary materials management
- industrial ventilation and air-conditioning

Faculty of Metallurgy and Materials Science
- environmental protection and waste utilisation

Faculty of Mechanical Engineering and Robotics
- Devices used for the environmental protection
- Vibroacoustics and sound engineering

Faculty of Geology, Geophysics and Environmental Protection
- environmental geophysics
- water pollution control and environmental geotechnics
- geology and environmental geochemistry
- environmental protection in oil and geothermic geology
- geological environment management

Faculty of Mining Surveying and Environmental Protection
- environmental protection in planning and management
- environmental protection in the industry

Faculty of Foundry Engineering
- environmental protection in the foundry engineering

Faculty of Non-Ferrous Metals
- recycling of metals and environmental protection

Faculty of Drilling, Oil and Gas
- environmental protection in national economy

Faculty of Physics and Nuclear Techniques
- environmental physics

Environmental education at the University of Mining and Metallurgy comprises not only education of students. Problems of environmental protection are also included into educational program of post-graduated and doctorate studies, at almost all Faculties of the University of Mining and Metallurgy. Moreover, the Walery Goetl School of Environmental Protection and Engineering works as a part of the University of Mining and Metallurgy. Activities of this school are aimed at [8] "education, propagation and presentation of the outstanding technical and technological solutions, in the national industry and economy, due to elimination, or at least limitation, of polluting emissions into the natural environment, right within the emission source".
A great number of scientific studies and examinations related with the environmental protection are conducted and published at the University of Mining and Metallurgy, and their results are also used in its educational process.

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