ECOLOGICAL EDUCATION OF ENGINEERS

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Abstract: *The state of environmental condition in Poland and two other countries of Middle-East Europe, compared with Western Europe and USA, has been outlined. Professional and intellectual potential of multidisciplinary engineers, particularly technologists, with respect to limitation of natural environment degradation, has been discussed. A program of environmental education of engineers implemented at the University of Mining and Metallurgy in Cracow, has been presented.*

Keywords: environmental protection, environmental education.

1. Introduction

Political and economical transformations in the late eighteenth and early nineteenth revealed fatal condition of the natural environment in Poland and in other countries of Middle-East Europe as well. The former efforts directed towards public announcing the best statistical indicators in such industry lines as metallurgy, coal mining or fertiliser consumption, which were intended to inform media about the domestic industry development, trivialised social, and particularly ecological problems. In former times, examinations of the condition of natural environment were insufficient, the data were incomplete, and their publication was difficult or simply impossible. Only afterwards the historical landmark, the fatal condition of the domestic natural environment, backwardness within this discipline, particularly as compared to highly developed countries, have been revealed.

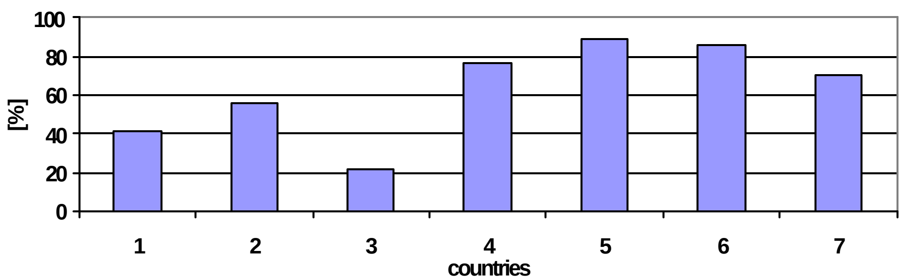

fig. 1.1

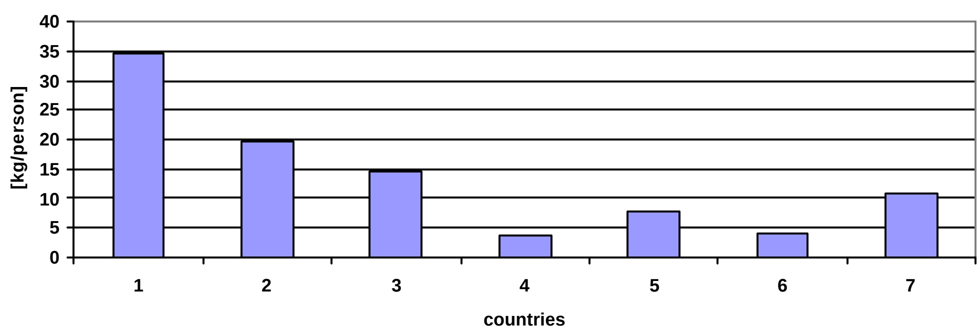

fig. 1.2

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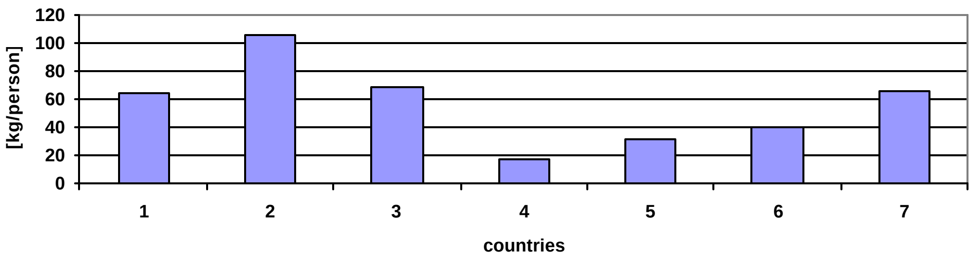

fig. 1.3

Fig.1, where:
Fig.1.1 Percentage of the population serviced by sewage treatment plants [%];
Fig.1.2 Sulphur oxides emissions [kg per capita] – data for 1,3 and 6 comprise only SO_2
Fig. 1.3 Dust emissions [kg per capita].

Typical data describing environmental condition in the middle of the political transformation, i.e. in the year 1996 are shown in Figure 1 [1]. These data refer to three countries of our region: 1 – Poland, 2 – Czech Republic and 3 – Hungary, and for comparison, to four developed countries: 4 – France, 5 – Germany, 6 Great Britain and 7 – USA.. As seen from the presented diagrams, the situation within the countries of our region was practically twice worse than adequate situation within western countries. As seen in Figure 2, if the emissions volume is analysed with reference to economical output measured on the basis of gross national product, we can prove that the emissions volume was more than a dozen times greater [1].

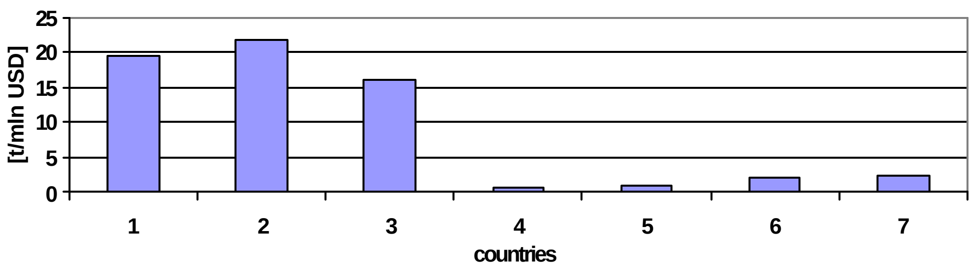

fig. 2.1

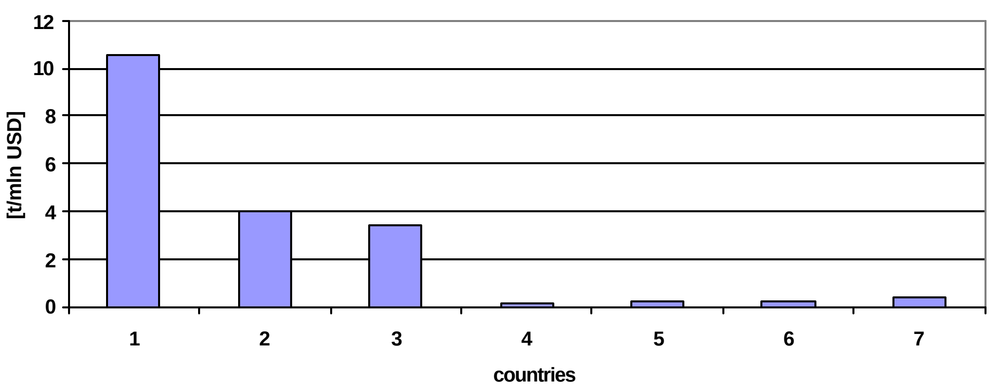

fig. 2.2

Fig.2, where:
Fig.2.1 sulphur oxides emission [t/mln USD] – data for 1, 3 and 6 comprise only SO_2
Fig.2.2 dust emissions [t/mln USD].

Volumes of other volatile pollutants, treatable sewage and produced wastes are also – slightly speaking – unsatisfactory. The overdue problems, such as management of collected industrial wastes of the volume estimated as 2 to 4 billion ton, for example, have been still not solved. Also new problems, such as management of the growing volume of non-returnable packaging call for urgent solution. Whereas tens of percent of used packages are recycled in Western Europe, the same value reaches only from few to a dozen percent in Poland. The rest is deposed – unfortunately – on better or worse managed landfill sites.

Because of technological retardation, volume of the problem and cost and the rate of improvement of the environmental condition is very slow. Moreover, some positive effects result not only from implementation of ecological technologies but also from the production output decline within numerous industrial branches. For example, reduction of overall sulphur dioxide emission in Poland is shown in Figure 3 [1].

Environmental activities have to be intensified in our country. This necessity is related from one side to growing ecological knowledge of our society, as well as to – apart from the enormous cost – necessity of our adaptation to the European Community requirements. According to estimations made by Polish government, cost of implementation of all environmental requirements defined by the European Community accounts for about 34 billion EURO, what is equivalent to about ¾ of our national budget [2]. It should also be noted, that several great social and economical reforms have recently been implemented in Poland, and that we still have to repay an external debt. So in the light of this situation, environmental protection problem is – apart of its importance – only one of many actually solved problems.

Degradation of natural environment accompanies mainly processes of raw materials excavation and products manufacturing, it takes place during their exploitation and processing, as well as it is caused by disposal of used products. That is why, the role of engineers in activities directed towards limitation of the environmental degradation create the problem of particular importance. And not only those engineers, who recently graduated from faculties of environmental protection. As the problem is – as was emphasised above – of the great-scale and multi-factor character, it should be solved by interdisciplinary specialists. Their potential will be discussed below, following an article [3], on the background of the product life history.

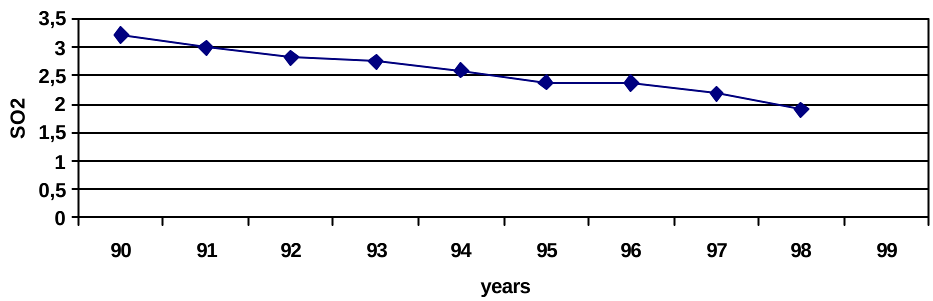

Fig. 3 Total emission of SO_2 [mln t / year]

2. ECOLOGICAL ACTIVITIES OF ENGINEERS

Designer has particularly essential influence onto the environmental condition. Such product features as mass, durability and recycling ability, i.e. features directly influencing natural environment, depend on the designer. Detailed recognition of operational conditions of the designed product and use of suitable materials allow to reduce the product mass. The lower mass the lower material consumption, that is lower production volume, and consequently, lower pollution of the natural environment. If the product is driven, the lower mass may result in lower energy consumption, and consequently, lower pollution of natural environment. Use of suitable materials and protective coatings may considerably extend operational period of a product. The extension of the product operational period results in reduction of yearly material consumption, thus like was described before, it also results in the limitation of the environmental pollution.

One day the products get used. Implementing constructional solutions allowing to disassembly the used products, a designer is able to increase stream of recycled products, and consequently, to limit stream of used products deposed within disposal sites.

The greatest environmental degradation occurs, as a rule, during excavation of raw materials and products manufacturing. The manufacturing process usually comprises a number of stages, and is very often accompanied by transport of the materials at big distances. The role of technologists and engineers is particularly important at this stage, as they are responsible for the implementation of material-saving and energy-saving technologies. And less material and energy consumption obviously results in reduced environmental pollution. This problem, illustrated by the example of transformations implemented in Polish metallurgy, will be discussed in details in the next chapter.

The products of manufacturing sub-system are, via distribution sub-system, transferred to potential users. Exploitation specialists have also essential influence onto the environmental protection. That refers particularly to operation of engine-driven objects. Activities aimed at reduction of fuel and energy consumption are advantageous not only from economical but also from ecological point of view. Reduced fuel consumption is equivalent to less volume of combustion gases, whereas, reduced consumption of electric energy is equivalent to less volume of pollution generated by electric power plants. Also activities aimed at elongation of the product operational period, as was mentioned before, are of ecological character.

Recycling sub-system activity is aimed mainly at protection of the natural environment. It comprises collecting of used products and their preparation for recycling. Obviously, the greater flow of recycled products the more benefits for the natural environment. That is why activities of recycling specialists should be directed towards creation and development of purchasing points network, as well as towards implementation of effective recycling technologies.

So far, an outline of how various specialists related to product designing, its manufacturing, exploitation and recycling, may influence natural environment degradation, has been discussed. Obviously, also the other entities and institutions may develop and conduct environmental activities. For example, politicians having decision-making potential related to legal and financial regulations may considerably influence the problem of environmental protection.

3. EXAMPLE OF ECOLOGICAL ACTIVITIES IN STEEL METALLURGY

During the last decade, volume of steel production output in Poland was held at the level of about 10 [mln Mg / year]. Great variety of ecological activities have been implemented during this period. They comprised mainly reduction of emissions of volatile and liquid pollutants, as well as waste management problems. Up-dating of manufacturing technologies, which apart from improvement of metallurgic product quality and reduction of production cost, considerably improved environmental conditions, have also been implemented. Particularly bid changes have been made on the field of pig iron processing. The traditional technology of ingot mould casting and break down mill rolling was gradually replaced by continuous slab casting technology (COS). Use of this technology in steel processing is shown in Figure 4 [4].

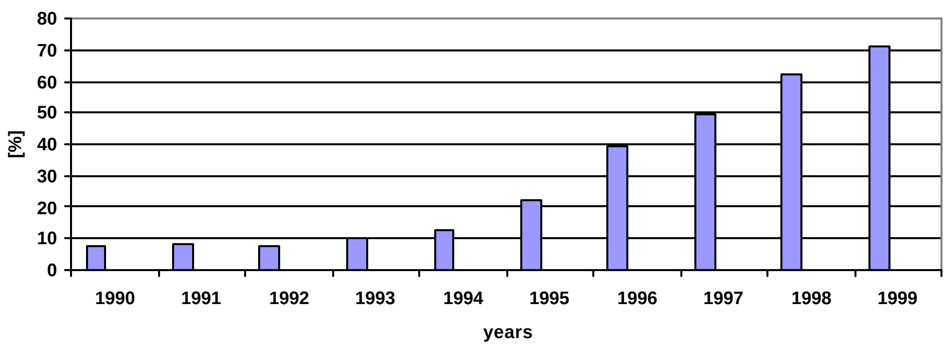

Fig. 4 Use of continuous slab casting technology in total steel processing.

Implementation of the continuous slab casting system gives advantageous ecological effects within two areas: within metallurgy itself, and within non-metallurgic sectors as well. Ecological effects in metallurgy comprise reduction of energy consumption (heat and electric energy) reaching from 75 to 85[%]. As was mentioned in previous chapter, limited power consumption is equivalent to limited emission of pollutants produced during energy generation. Ecological effects within non-metallic sectors are much more complex. During the last decade, Polish metallurgy expressed stabile demand for scrap used for steel-making. This demand accounted in average for 0.52 [Mg of scrap / Mg of steel]. The demand was satisfied by use of local and external scrap. The local scrap is produced in steel plants during processing of steel into rolled products. Major part of this scrap is produced within initial processing phase, and its volume depends on technology used. In traditional technology, steel is cast into ingot moulds, then it is rolled with use of breakdown mill, and finally, both ends of rolled slab are cut off. In case of the continuous slab casting system, single slab is a result of one or more casts, thus volume of produced scrap is considerably reduced. Decrease of unit volume of local scrap [kg of scrap / Mg of steel] vs. increasing implementation of continuous slab casting system [%], is shown in Figure 5. The diagram was based on data from the period from 1990 to 1999. As seen from the diagram, in early nineties when participation of the continuous slab casting system in steel processing accounted for less than 10 [%], about 240 [kg] of local scrap was returned for each Mg of produced steel. In the year 1999, when participation of continuous slab casting system increased up to 71 [%], only 131 [kg] of local scrap returned for each Mg of produced steel. In this situation, volume of external scrap used had to be increased. External scrap comprises post-production and post-amortisation scrap. Post-production scrap is generated within plants processing steel products, i.e. within plants of machine-making, metallurgic, locomotive and other industries. Post-amortisation scrap comprises scrap derived from liquidated plants and constructions, and scrap derived from family households as well. This scrap which is derived from used products such as motor-cars, cookers, refrigerators etc. comprises scrap of the lower quality. It has diversified composition and is polluted by enamels, varnishes and components made of other materials, for example plastics. However, in the situation when implementation of continuous slab casting system reduced delivery of the local scrap, metallurgy had to use also scrap of the lower quality. Recently, volume of the external scrap used has increased from 2.2 [mln Mg] in the year 1992 to 4.1 [mln Mg] in the year 2000 [4]. Such growth could occur in result of use of the lower quality scrap. Thus we may conclude, that the advantage of the implementation of modern continuous slab casting technology is that the great stream of scrap did not pollute natural environment, and what is more, that it has been recycled in production process. The example presented above illustrates great influence of technologists onto limitation of environmental degradation.

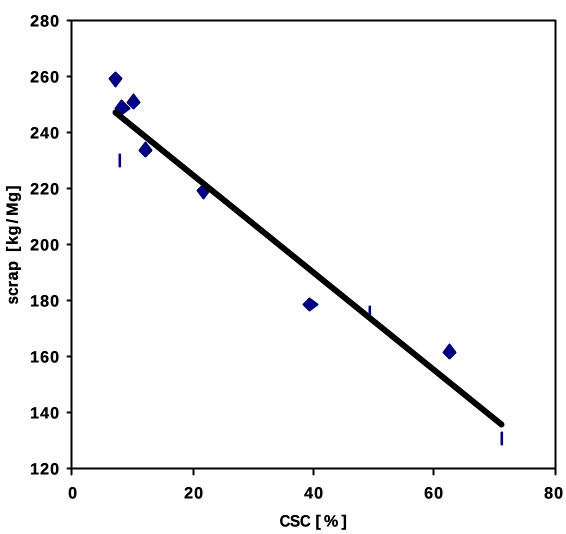

Figure 5. Decrease of local scrap volume vs. increasing implementation of continuous slab casting system within steel processing.

4. ENVIRONMENTAL EDUCATION OF ENGINEERS

As results from the analysis discussed in preceding chapters, a number of various specialists can influence environmental degradation. Apart from specialists who operate environmental protection equipment, also specialists dealing with designing, manufacturing, exploitation and recycling of the final products have fundamental influence onto the environmental problems. As an average age of the university graduate is 24 years, and an average age of the retired man is 65 and woman 60 years alternatively, the specialists in question comprise people who graduated during the period between the year 1960 and 2001. Changes of the number of specialists graduated from technical schools of engineering within this period are shown in Figure 6.

As seen from the diagram, about 2/3 of professionally active engineers graduated from their universities within the period when ecological problems were considered as marginal problems. Also after political and economical transformation at the turn of 89/90, improvement of environmental education was developing gradually.

However, before thousands of engineers of various lines take active part in environmental activities, they ought to be deeply involved with these problems, as well as they must learn how to solve these problems.

In order to meet these needs, the Stanislaw Staszic University of Mining and Metallurgy in Cracow, one of the greatest technical schools of engineering in Poland, implements a program of additional education for its graduates, held at post-graduation courses. This education is held at several Faculties, and usually the environmental problems are tailored to educational profile of given Faculty. It should be pointed out, that because the University of Mining and Metallurgy deals with disciplines which are not friendly to the natural environment, the environmental problems had been noticed here a long time ago, being involved into the University's educational programs.

During the last decade, ecological education of students and graduates has also been developed.

In the next academic year, implementation of the following post-graduation studies, directed towards environmental problem, is planned [5] :

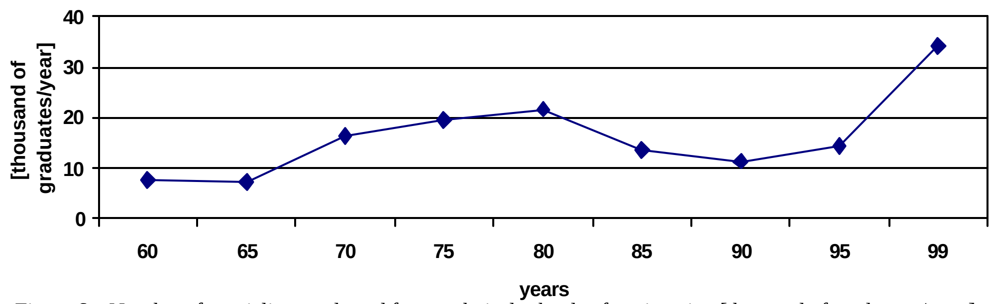

Figure 6 Number of specialists graduated from technical schools of engineering [thousand of graduates / year]

Faculty of Mining:

– Water supply and sewage disposal in mechanical processing and environmental protection,
– Technology and economy of environmental engineering.

Faculty of Geology, Geophysics and Environmental Protection:

– Geophysical research in the Earth surface protection,
– Protection of natural environment and mineral resources.

Faculty of Materials Science and Ceramics:

– New trends in glass production in aspect of protection and formation of natural environment.

Faculty of Drilling, Oil and Gas:

– Environmental protection in national economy,
– Environmental protection within urbanised areas,
– Technical problems and environmental protection in gas engineering in context of the European Community integration.

Faculty of Physics and Nuclear Techniques:

– Chemistry with elements of environmental protection.

Faculty of Mechanical Engineering and Robotics:

– Designing and exploitation of electrofilters.

Faculty of Me tallurgy and Materials Science:

– Heat economy, industrial furnaces and environmental protection.

Faculty of management:

– Natural environment economy.

The Walery Goetel School of Environmental Protection and Engineering has been conducting its activity within the organisational structure of the University of Mining and Metallurgy for few decades years.

Another form of additional engineer training held at the University of Mining and Metallurgy in Cracow comprises organisation of numerous conferences and research seminars aimed at the environmental problems.

Refereces

[1] "Statistical Yearbook of Poland 1990, ..., 2000", Central Statistical Office, Warsaw, 1990, ..., 2000.

[2] D. Pszczó³kowska "Clean up faster", "Gazeta Wyborcza" 15.02.2001.

[3] W. Jod³owski, B. Karwat, J. Kowal, B. Sapiñski "Protection of natural environment as a fundamental element of modern engineer's education" International Conference on Engineering Education. August 2000, Taipei, Taiwan.

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[5] Guide book of the University of Mining and Metallurgy for 2001/2002, Educational Department of the University of Mining and Metallurgy, Cracow 2001.