THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI.
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 4 – 2011, ISSN 1453 – 083X

OPPORTUNITIES TO ANALYSE THE POLLUTION IN METALLURGICAL INDUSTRY

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ABSTRACT

The metallurgical industry is a highly polluting economic sector. In order to establish measures to minimise the pollution, new methods are needed to analyse such processes.

This article analyses the following possibilities:

- *thermodynamic analysis;*
- *analysis with system theory elements;*
- *characterization of pollution as global phenomenon of soiling;*
- *possibilities of maintaining a balance between the economic development and pollution.*

KEYWORDS: pollution, analysis, life cycle

1. Introduction

In metallurgy, the life cycle phases of a product we are mostly interested are:

– **product manufacturing**, in which the material resources and energy, through the technological process, are transformed into product;

– **use of the product**, in which, through the *disintegration of the material and scrapping* (by destruction) of the product, it is transformed into secondary material (waste).

Both phases, objectively, generate pollutants. Some of pollution assessment methodologies that can be used for scientific and practical purposes are represented by:

– thermodynamic analysis;

– analysis with system theory elements;

– characterization of pollution as global phenomenon of pollution;

– possibilities of maintaining a balance between the economic development and pollution.

2. Thermodynamic analysis

The evolution of manufacturing processes, use and generation of pollutants (among which there are wastes, too) is governed by the laws of thermodynamics.

2.1. Analysis using the first principle of thermodynamics

It is recommended that pollution analysis using the first principle of thermodynamics showed to be made by taking into account the considerations below.

- The scheme of the simplest operating system includes the following metallurgical measures (Fig. 1):
  - * input measures;
  - * output measures, which consist of:
    - – useful measures;
    - – losses.
- It is proposed that the pollutants (materials and energy transferred to the external environment) should be considered *losses* [1].
- The idea that pollutants are system losses should be reported to the first principle of thermodynamics, that there is no system to function without losses (*zero losses*). In these circumstances, the concept of zero waste plant (launched also in metallurgy), is not justified in terms of thermodynamic. It must be accepted and operationalised as target [2].
- The zero waste status can result only in case of cancellation of the technological process (production stoppage).

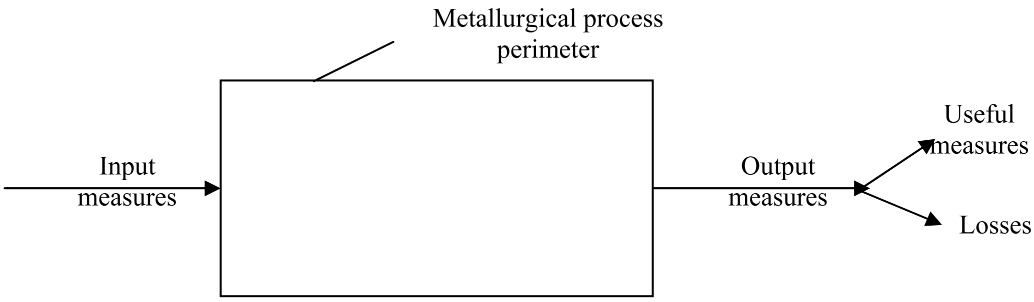

Fig. 1. *Scheme of thermodynamic operation of a technological process.*

- A similar situation concerns the risk analysis. Any industrial activity is associated with risks, reason why the target of environmental policy, of **zero risk** level, is unrealistic, because it can only be achieved by stopping the production [3]. To run the industrial activity, ***we should be aware of the existence of potential risks, to accept the consequences of some of them*** and / or ***to take measures to minimize unacceptable risks.***

2.2. Analysis using the second principle of thermodynamics

In this case, it is an entropic analysis, where two important thermodynamic measures are used:

– *Entropy, S,* which is a measure of the degree of disorder (chaos) in the organization of matter; where the growth of S characterizes the spontaneous tend of the systems to chaos;

– *Negentropy (antientropia), nS,* which characterises the level of the ordered organisation of matter and energy.

For analyses of pollution phenomena using the second principle, we make some recommendations:

- As losses to the environment, *the pollutants represent a state of disorder*. It follows that the generation of pollutants is an anti-entropic phenomenon, inadvisable in terms of the second principle of thermodynamics [1].
- The manufacturing phase (process technology) is an activity to increase the degree of order on the path *natural resources - metal product*. It may be concluded that *advanced processing* of natural resources is recommended in the pollution minimize policies.
- The degree of disorder (entropy S) of pollutants increases with increasing the duration of keeping them in the environment. It is recommended into a flow designed with the reintegration (recirculation, recycling, or regeneration) of wastes *to reduce the number of reintegration*.
- The degree of disorder (entropy S) of wastes increases with increasing the distance between the location of generation and the location of reintegration.

In this situation, it is recommended:

– To decrease the distance between the two locations;

– To use internal reintegration (waste recovery inside the perimeter of the facility that generated them) instead of the external reintegration (recovery of wastes in other locations).

3. Analysis with system theory elements

Analysis of pollution phenomena and pollutants can be also done by using the systems theory. We take into account the aspects presented below.

- *It is proposed* that in the structure of the natural system, the pollution should be considered as *disturbance process*, and the pollutants – *disturbance measures (noises)*, (Fig. 2).
- According to the systems theory, *a certain amount of noise must exist to maintain the order*, because it provides information on system status. It is concluded that *maintaining the life* of the system requires a certain minimal amount of disturbance.

It is argued in this way that **zero pollution** *is not only impossible to be reached, but a certain amount of pollution must be kept to a minimum rate*.

- It is proposed that the routes of the secondary materials reintegration should be considered *feedback paths* (Fig. 3).

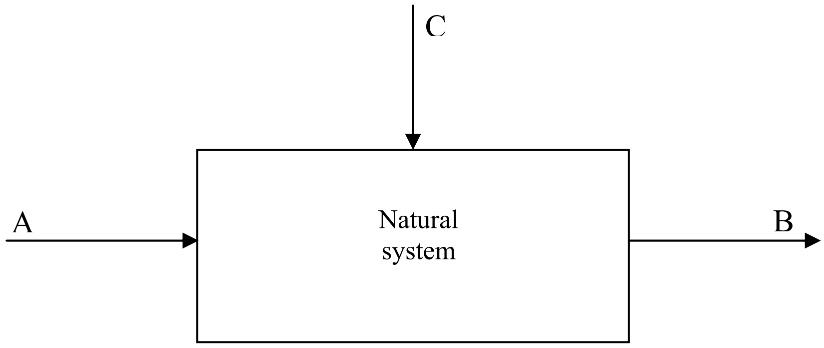

Fig.2. *The simple structure of the natural system.*
A – input measures (control measures; measures to transform the natural ecosystems);
B – output measures (parameters regarding the productive capacity in resources, parameters for rational use of resources, parameters on carrying capacity); C – disturbance measures (pollutants, including wastes).

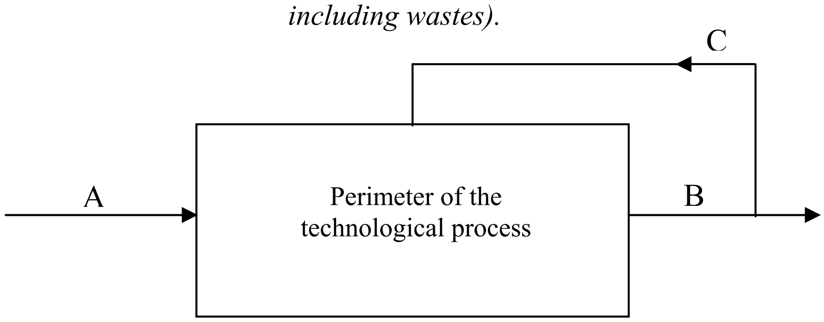

Fig.3. *Diagram of the technological process as a system.*
A – input measures; B – output measures; C – feet-back path of the wastes.

- If the reintegrated secondary materials (wastes) are subject of feed-back, they can perform two functions:
  - Transport of materials (secondary material resources) and energy (secondary energy resources);
  - Information transportation represented by the technological deviations that led to wastes; reintroduced in the primary sequences of the flow, such information becomes levels of the system (self) control.

- The self-adjustment ability of a system, i.e. the capacity of self-sustainability of the natural system in its relations with the economic and social system, depends on the diversity of its behaviour. We deduct from this the *need to diversify* the base of raw materials and energy of metallurgy, on the one hand, and the *metallurgical production*, on the other one.
- The losses to the environment (pollution) must be correlated with another rule of systems theory showing that in a systemic evolution, *the presence of losses stimulates the development*.

4. Characterization of pollution as a global phenomenon of soiling

One of the meanings that can be given to pollution is the soiling. Etymologically, by its Latin origin (poluo-polluere), the term *to pollute* means *to soil*, and *pollution* can be interpreted as soiling. There are many situations (economic, social and environmental) that can be treated as soiling phenomena (quality deterioration). So, it becomes possible a new approach of the phenomena of pollution, by extending the application of the environmental laws in other areas (industrial and even social). In this context, we can say that there are:

– *conventional pollution phenomena* including the known classic cases on the related environmental pollutants → environmental factors → quality of life;

– *unconventional pollution phenomena* relating to the process interaction between environments and special items, of which qualitative alteration can be studied based on principles of ecology.

For the second case, this article refers to two situations: use of metallic implants and the use of metal ornaments. The interactions between them and the substances of human body are considered to be a process of pollution. The process of interaction between human body and the objects mentioned above is in fact a process of soiling them or their bodies.

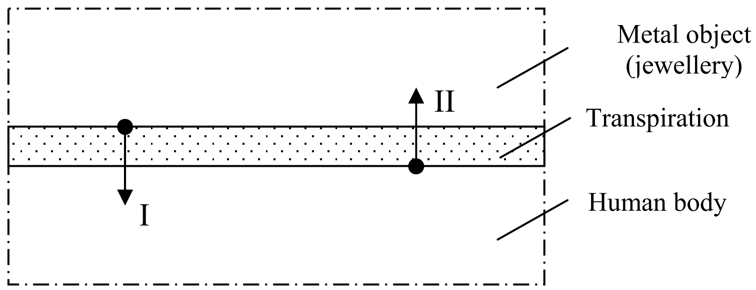

Fig. 4. *Examples of unconventional pollution (soiling): I) direct pollution; II) indirect pollution.*

It can be conclude that it is a process of bi-univocal pollution (Fig. 4):

– *unconventional direct pollution*, which means pollution on the relation *metal object → human body* and refers to the negative impact of the object on the body;

unconventional indirect pollution, which means pollution on the relation *human body → object* and refers to the negative impact of body on the object, with direct implications on the duration of its social utility.

5. Possibilities of maintaining a balance between the economic development and pollution

Optimizing the correlation between development and pollution is a fundamental issue of knowledge in today's society. It is also known as the *contradiction* between the *human activity* and *environmental conditions*.

The currently recommended measures to mitigate this contradiction are placed in two categories:

– measures of technical and technological nature;

– measures of social-political-administrative nature.

In this article, we analyse a possible situation in metallurgy.

- The target-binding development in metallurgy can be characterized by the production of steel P [tonnes of steel / year]. Under development strategies, it must have an upward trend (Fig. 5, trend 1).

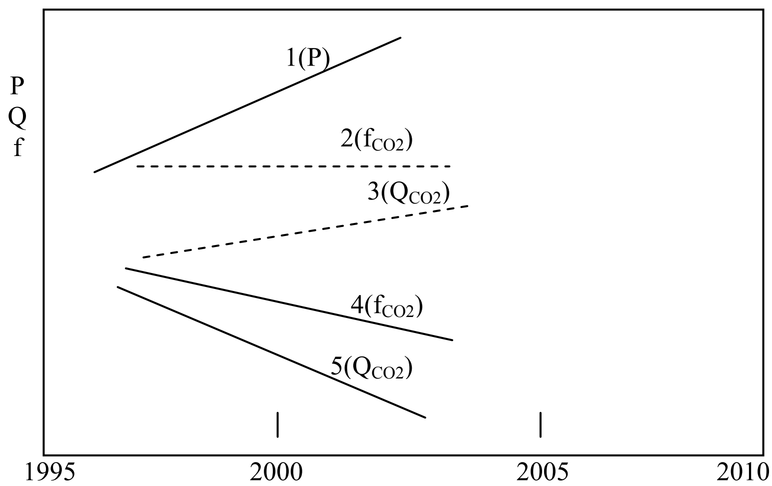

Fig.5. *Dynamics of relationship between development and pollution.*

- Manufacture of steel is accompanied by CO_2 generation. The process is evaluated using the emission factor $f_{CO_2}[t \cdot CO_2 / t \cdot steel]$. Where no action is taken to minimize the CO_2 emissions, the factor f_{CO2} has constant values (Fig. 5, trend 2).
- The CO_2 quantity is Q_{CO2}:

$$Q_{CO_2} = P \cdot f_{CO_2} \ , [t \cdot CO_2 / year]$$

Where no action is taken to minimize the CO_2 emissions, this indicator is trending upward (Fig. 5, trend 3).

- By taking measures to decrease the CO_2 emissions, the factor f_{CO2} is trending downward (Fig. 5, trend 4).
- By reducing f_{CO2}, we can also reduce Q_{CO2} (Fig. 5, trend 5), although P increases.

6. Conclusions

∗ It is proposed that pollutants should be considered *losses* from the technological process perimeter to the environment.

∗ It is proposed that pollutants should be considered disturbances (noises) in the natural system.

∗ The activities and the anti-entropy actions determine the reduction of the pollutants quantities.

∗ To use the environmental laws to analyze the phenomena in different areas, it is recommended for pollution to be considered a soiling process.

∗ To solve the contradiction between development and pollution, it becomes necessary to minimize the emission factors given by the industrial activities.

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