THE ECOLOGICAL ESSENCE OF THE METALLIC MATERIALS DEGRADATION PROCESSES

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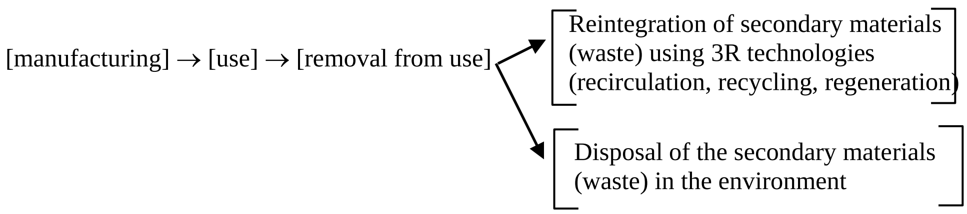
In this paper are defined the process of degradation of metallic materials and engineering of material degradation, as a new scientific branch studying phenomena. It analyses the situation in the convergence zones between the technological system (S.T.) and the natural-ecological system (S.N.E.), upstream area to S.T., where the degradation of materials negatively influences the sustainability of S.N.E. and the area downstream from S.T., where the degradations of materials negatively influences the durability of S.N.E. From diminishing the negative effects of material degradation, the positive influence of 3R (recirculation, recycling, regeneration) technology on waste re-engineering is shown.

Keywords: sustainability, durability, materials, ecology, degradation

1. Introduction

The **lifecycle of a material** consists of the key sequences given in the diagram:

For the materials engineer, the lifecycle is the contour of two fundamental events [2, 6]:



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- *Achieving high performance,* conducted mainly in the manufacturing stage; it is the phase in which the *advanced material* acquires the properties and characteristics imposed by its field of use, on the basis of *successive processes of superordering* of the matter (substance);
- *Degradation,* occurring mainly in the use stage; it is the phase in which the *decrease in the ordering degree* of the matter (substance) occurs; the result of this event is the transformation of the advanced material into *secondary materials* (waste and residues).

The **degradation of material** is the *fundamental process under which the functional integrity of the material is negatively affected* or, more specifically, the *alteration of product quality over the lifecycle*.

Depending on the development stage of the techniques and technologies applied in the materials field, the degradation can be studied on the basis of two paradigms:

* *The classical technical and technological paradigm;* in this case, the material degradation is studied as a result of the interconditioning between it and the destructive factors of the *environment of use;*
* *The ecological and technological (ecotechnological) paradigm;* in this case, we are interested in the interactions and interconditioning between the degraded material and the environment quality *(the natural-ecological system, N.E.S.)* [8].

Developed in the spirit of the *durable-sustainable development concept*, it considers that, in the human sphere, the *natural-ecological system (S.N.E.)* is of primordial importance, being called the *foundation system*, because it is:

– Provider of natural resources (n.r.);
– Storage basin for polluting waste.

In contrast to it, the *technological system (T.S.),* which is a manufacturer of *degradable materials*, is called *parasitic system* [3, 4].

2. Materials and methods

➢ The **materials** we have used were *documentary and informative scientific materials* on the basis of which it is possible to move from the *specialized knowledge* (mostly material manufacturing research) to the *global knowledge* (correlations between the material and other systems);

➢ The **methods** we have used were:

– Interdisciplinary research;
– Use of the eco-technological paradigm [8].

3. Results and discussions

3.1 Interactions and interconditioning between T.S. and N.F.S.

The interactions and interconditioning of the degraded material (Dg.M.) are studied in three areas (Figure 1).

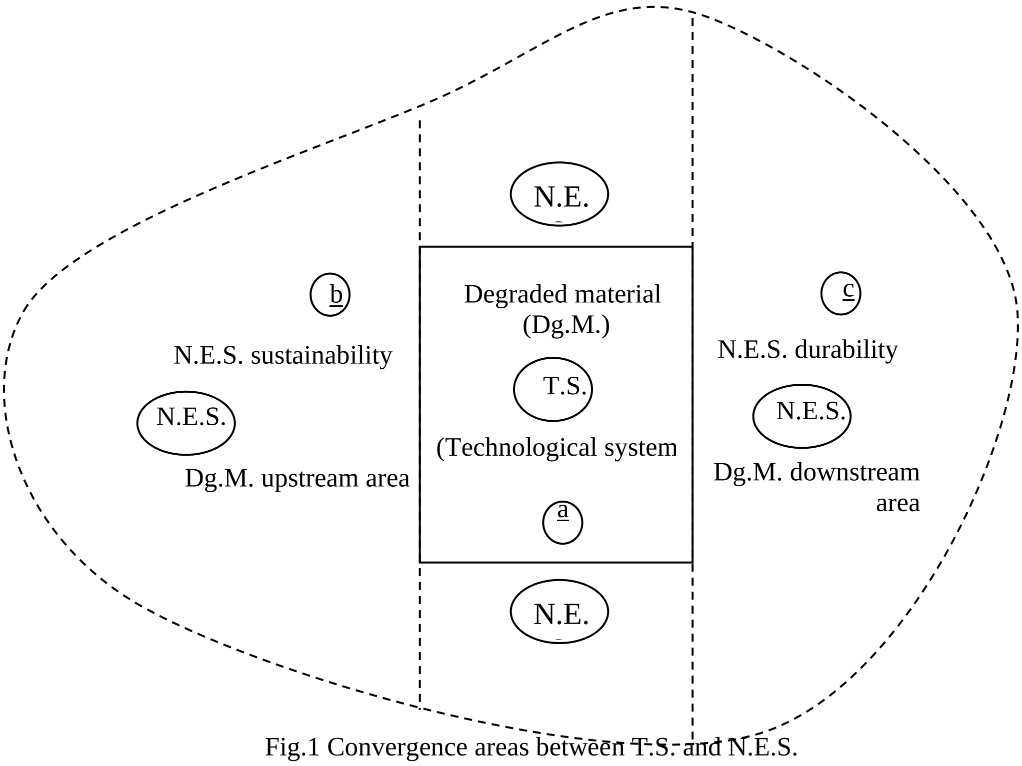

Fig.1 Convergence areas between T.S. and N.E.S.

a**) The Dg.M. area**

The *resistance to degradation, Dg.R.* is the main function used to assess the material behaviour. It is a complex and unclarified property so far, because it spreads throughout the entire lifecycle (for example, the non-metallic inclusions generation in alloy-making processes is the reason for degradation initiation).

b) The Dg.M. upstream area

* The *Dg.M. upstream area* is the natural resources supply area for the materials manufacture and use;
* The N.E.S. potential to *sustain* the technological processes with natural resources is the function called *sustainability*, measured by the parameter called *support capabilities*;
* As the material degradation determines the *size of annual consumption of material resources,* it negatively influences the sustainment capacity of N.E.S., which disturbs the *ecological balance* between the natural-

ecological system (N.E.S.) and the technological system (T.S.) that produces materials.

c) The Dg.M. downstream area

∗ The Dg.M. downstream area is the area where N.E.S. acts as *storage basin for polluting residus* generated by degradation;

∗ The *pollution* is currently considered the most important *shock-type stress* acting on N.E.S.;

∗ The N.E.S. potential to withstand the pollution-induced shock stresses is measured by the function called *durability*;

∗ Similar to the mechanical shock stresses assessed by resilience, the pollution, as system shock, is assessed by the *ecological system resilience.*

3.2. The reduction of the negative effects of degradation of materials

The M.D.E. designs specific policies and technologies able to mitigate the negative effects of degradation. We are going to present some aspects in this respect concerning the *siderurgy*, the industrial branch producing *steel*, which fulfils the *multifunction of durable and sustainable material*. We will insist on the performance of *siderurgy* and steel that deal with the *fight against degradation*.

a) One of the fundamental ways is the *maximization of the use phase duration*, D_u [years]. In this case, I.D.M. recommends D_u to be calculated from two parts:

$$D_u = D_{u_1} + D_{u_2} \quad \text{[years]} \qquad (1)$$

According to the diagram presented in Figure 2, the reduction in car pollution reported by the in the above relation:

- D_{u_1} is the duration of the actual use phase that runs from manufacturing to the removal from use;

- D_{u_2} is the duration of pseudo-use, additionally induced by the re-integration of secondary materials (waste) by 3R technologies, after the removal from use.

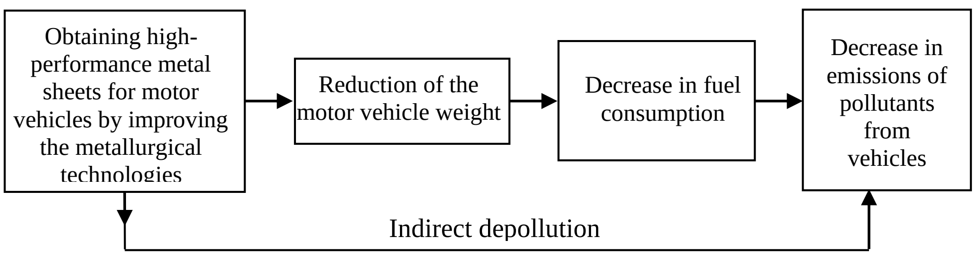

Fig.2 Diagram of indirect depollution event

b) The siderurgy undertakes the responsibility to obtain *added value*. In this context, *it ennobles the ore* (in a car, 80% of the ore supplied by the environment is exported) [9].

c) By providing *flexibility and compatibility*, the siderurgy adapts to changes induced by the suppliers and consumers.

d) The siderurgy implements *forward-looking efficiency policies*, assuring the consumers about the maximization of the use phase.

e) The siderurgy *improves its relationship with the media*, in order to publicise its achievements, which are often arrogated by other specialists. Two examples are given in this respect [13]:

- ❖ The construction specialists are reporting the reduction of the reinforced concrete ceiling from 30 kg/m^2 (in 1955) to 6 kg/m^2 (in 2000). In fact, this is thanks to the steelmakers who are currently manufacturing much thinner rebars, but with superior performance.
- ❖ A second example refers to the so-called indirect depollution phenomenon encountered in motor vehicles. motor vehicle manufacturers is thanks to the steelmakers who are currently manufacturing thin metal sheets of superior performance, which lead to the reduction of vehicle weight, fuel consumption and, therefore, the reduction of noxious emissions.

f) The siderurgy has already launched the *new product policy*, based on which it makes durable and sustainable materials.

g) The siderurgy has assimilated the *steel-plus concept*, which involves its transformation from simple material to *construction systems* realised by the siderurgy.

h) In the *industrial culture*, the steel is a *conscientious material*, concerned with the accumulation of knowledge that leads to the reduction of degradation effects.

i) The steel is a *stubborn material*, i.e. by reincarnation in the recovery of waste it comes back and does not give up the struggle against degradation, which is permanent.

j) In addition to the *material flow* sent by the steel industry to the social system (S.S.), it is also transferring an *immaterial flow*, materialised in the *joy of living* of the consumer of high-performance metal products.

k) Steel is permanently concerned with the *emotional state* induced among metal users. Thus, at the Hanover International Exhibition (2000), a church built exclusively of steel was exposed and this event generated the answer *the church trusts in steel* [9].

l) The steel is an *industrial fitness* practitioner. After the steelmaking process, when it is still weak, it enters a *fitness room* (heat treatment workshop), is subjected to an *industrial massage* (heat treatment), and comes out hardened and able to fight the degradation [10].

m) The house (family) in which the steel *lives and is educated* is the *sustainable siderurgy*, an industrial branch without which the *durable and sustainable development* in Romania cannot be imagined [11, 12].

4. Conclusions

Summarizing, the *ecological essence of materials degradation* consists of its negative influence on the two fundamental functions of N.E.S.: sustainability and durability.

The waste *reintegration (recovery) technologies* based on the *3R technologies* (recirculation, recycling, regeneration) become mandatory, because [1, 7]:

- In the Dg.M. downstream area, the amount of waste that could turn into polluting waste is reduced;
- In the Dg.M. upstream area, the waste can become *substitute* for the natural resources;
- From the informational point of view, the waste carries *information* about the causes that generated the degradation.

For the metal industry to be sustainable and durable, the following issues become mandatory:

- Maximizing the resistance to degradation;
- Minimizing the consumption of natural resources [4];
- Minimizing the quantities of pollutant residues deposited in N.E.S.

The materials engineers have to define and characterize certain important functions, such as: the resistance to degradation, the sustainment capacity and the ecological system resilience;

It is also interesting to explain the information conveyed by waste related to the causes of degradation.

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