NEW SCIENTIFIC BRANCHES OF THE SUSTAINABLE-DURABLE DEVELOPMENT IN THE METALLIC MATERIALS ENGINEERING

Avram NICOLAE[1], Roxana Mariana DUMA[2]*, Cătălin Ştefan GRADINARU[3], Andrei GRECU[4], Roxana DUMITRESCU[5], Sorin CIUCĂ[6], Maria NICOLAE[7]

The sustainable-durable development of the megasystem (MS), which represents the sphere of human existence, is based on the interactions between the four component systems: natural-ecological (SNE), social (SS), economic (SE) and technological (ST). It is proposed that the global knowledge of the interactions in the field of metallic materials be made with the help of new scientific branches: Ecometallurgy, Metallurgical Econology, Metallurgical Ecosociology and Engineering of Metallurgical Materials Degradation.

Keywords: sustenability, durability, metallurgical ecosociology, materials degradation

1. Introduction

Development means passing through progressive phases of transformation towards a higher evolution stage of the *human sphere of existence*, which has the size of a *megasystem **(M.S.)***, made up of four systems: natural-ecological (N.E.S.), social (S.S.), economic (E.S.) and technological (T.S.), which in turn are made up from a complex of living or non-living parts (elements, components) in a permanent state of *interactions* and *interconditionings*.

[1] Prof., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, duma_roxana2000@yahoo.com
[2] Eng., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, duma_roxana2000@yahoo.com *corresponding author:
[3] Pd. D. Student, Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, catalin_grdnr@yahoo.com
[4] Eng., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, andrei.grecu931@yahoo.ro
[5] S.l., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, roxana.dumitrescu@pub.ro
[6] Conf., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, sorin.ciuca@upb.ro
[7] Prof., Facullty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, nicolae_maria@yahoo.com

The megasystem has an eco-socio-economic-technological nature (M.S.-E.S.E.T.).

The *intersystem convergence zone* (co-development zone, eco-evolution zone) is the area where the optimization of interactions and interconditionings occurs.

In such a context, the **development** means the optimization of interactions and interconditionings in the *zones of convergence* among the four systems. When it comes to metallic materials industry, N.E.S. and T.S. takes priority (without neglecting the other systems).

For the development of M.S., N.E.S. must provide two potentials (two capabilities):

∗ *Capability to provide natural resources* to the other systems*;* this capability, as a fundamental characteristic of the system, is called **sustainability**;

∗ *Capability to withstand shock strains,* of which the most important is the *pollution;* this capability, as a fundamental characteristic of the system, is called **durability**.

The **sustainable-durable development** is the model (concept) of development, which, in order to ensure the current needs without negatively influencing the needs of the future generations, must be based, in the convergence zones among the four systems, on:

– Sustainability, assessed by the *carrying capacity*, and

– Durability, assessed by the *system resilience.*

Starting from the above issues, the Centre for Research and Eco-Metallurgical Expertise has designed and operationalized certain researches on:

♦ Knowledge of the interactions and interconditionings among the four systems;

and

♦ Systematization of knowledge in the new scientific branches, briefly presented below.

The specific systems and sciences related to them will be symbolized as follows: N.E.S. – by ECOL, S.S. – by SOC, E.S. – by ECON. T.S. can be represented by the metallurgical industry (META), manufacturer of metallic materials, and by the energy industry (ENERG), supplier of energy.

2. Results of research

The research results have been materialized in launching onto the market of **new scientific branches of sustainable-durable development**.

2.1. Ecometallurgy

The Ecometallurgy (Metallurgical Ecology) is the scientific branch whose objective is the theoretical and technical-technological knowledge of ECOL-META interactions and interconditionings. It studies the ways of minimizing the negative influences that the manufacturing of metallic materials might have on N.E.S. carrying capacity and system resilience.

The major policies studied and recommended by Ecometallurgy for the manufacture and use of metallic materials are presented below.

- Eco-technologies for preservation and conservation of the natural resources (eco-technologies with the minimization of specific consumption);
- Hypo-polluting eco-technologies (eco-technologies with minimization of process losses);
- Development methods in active circular system (eco-technologies of reintegration of the secondary materials through 3R technologies - recirculation, recycling, regeneration);
- Particular methods of maximizing the eco-metallurgical performance:
  - Purity of metallic materials - objective of industrial ecology;
  - Solving the *development-pollution dichotomy*;
  - Role played by metallurgy in the global warming phenomenon;
  - Applying the principle *"I act locally, but I think and respond globally*"

2.2. Metallurgical Econology

The interconditionings in the convergence zone among the natural-ecological, economic and energy systems are interconditionings of ECOL-(the first E)-ECON-(the second E)-ENERG-(the third E) type.

The **Industrial Econology** is the *scientific branch of research-development-innovation and the study discipline regarding the optimization of the policies for the prevention and control of pollution and specific consumptions of natural capital under conditions of economic efficiency and minimization of the energy needs.* It is the area of the 3E (economy, ecology, energy) or, to further emphasize the significance (power), it is the area of E^3. As a consequence, the *econologist* is the person with interests in the new field of econology. No special arguments are needed to admit that the econology is dealing, in particular cases, with 2E (or E^2) correlations: economics-ecology, economics-energetics or ecology-energetics.

If the Econology is operationalized in a particular sector, it can take the form of a specific discipline. Starting from such a premise, one can operate with what is called ***Metallurgical Econology***.

For this scientific branch, the major objectives are:

- Knowledge of the contents (equivalents) in *primary energy* and *primary substance* for the natural resources, manufactured materials and residues;
- Optimization of specific energy consumption;
- Minimisation of the waste generated by energy consumption in META;
- Optimum economic level of (de)pollution;
- Use of energy and material eco-balances;
- Ecological efficiency of the reintegration of secondary materials;
- Saving the resources for manufacture and consumption of metallic materials.

2.3. Metallurgical Ecosociology

The interactions in the convergence zone between the ecological, social and technological systems are interconditionings of *ECOL-SOC-TEHN* type.

The **Industrial Ecosociology** is the scientific branch and academic discipline dealing with the *optimization of the impact of policies, technologies and industri*al *equipment on the quality of life, mainly through the quality of the environment.*

The industrial ecosociology is designed and operationalized starting from the idea that the *objective functions* in this field are the quality of environment and the quality of life.

The **Metallurgical Ecosociology** is an application of Industrial Ecosociology to be used when the T.S. is represented by the metallic materials industry.

It mainly focuses on aspects such as:

- The eco-socio-metallurgical projects – objectives of the sustainable-durable development;
- The role of techniques, technology and engineering in the ecosocial development;
- Paradigms and methodologies in the metallurgical Ecosociology;
- Functions and particularities of the metallurgical Ecosociology;
- Analysis of the ecosocial impact and ecosocial risk in metallurgy.

2.4. Engineering of Metallurgical Materials Degradation (I.M.M.D.)

The I.M.M.D. refers to the META-ECOL-SOC convergence areas.

The **Engineering of metallic materials degradation** deals with:

∗ The transformation processes mechanisms, i.e. removal from use of the primary materials and their transformation into secondary materials (waste and residues);

∗ Ecotechnologies used to maximize the life cycle of the material;

∗ Ecotechnologies for reintegration of the secondary materials generated by degradation;

∗ The ecological essence of the development phenomena:

- The degradation causes the increase of natural resources consumption (negative influence on N.E.S. carrying capacity);
- The degradation generates polluting residues (negative influence on N.E.S. system resilience).

The degradation categories studied by I.M.M.D. are:

➢ The *technological degradation (process degradation)* refers to the degradation of material during the manufacturing phase (generation of non-metallic inclusions, interactions with the constructive components of the facilities, etc.);

➢ The *usage degradation* aims at the degradation of material during the use phase of the life cycle;

➢ The *environmental degradation* describes the destructive interactions between materials and environmental factors;

➢ The *obsolescence* characterizes the premature replacement of materials for objective or subjective causes, legal or illegal.

3. Conclusions

- The research on metallic materials must be designed and operationalized on the basis of two modern concepts:
  - Sustainable-durable development;
  - Global knowledge.
- The dissemination of the specific metallurgical knowledge supports the idea that the metallic materials were and will be a sine qua non vector of the M.S. development.

- The new scientific branches demonstrate the paramount role of N.E.S. in the M.S., which is why it is called *foundation system*, and the others - *parasitic system*.

R E F E R E N C E S

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