THEORETICAL STUDY CONCERNING THE CHARACTERIZATION OF THE "ECONOMY-ECOLOGY-ENVIRONMENT (RESOURCES)"

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The paper is an approach to defining and operationalizing new models, which have to characterize relations between economy, ecology and environment. In this context, the authors present a new approach to the characterization of the relations between metallurgical processes, ecology and environment, using several types of analysis in the system "economy-ecology-environmental resources", based on the theory of information applied to the kinetics systems and theory chemical-metallurgical processes.

Keywords: resources, environment, thermodynamic analysis, negentropy, entropy and energy

1. Introduction

Within the analyses performed in order to characterize relations between economy-ecology-environment, dynamics of resources using have a great importance for a metallurgical engineer. Currently, many complicated issues face the world's population [1]. These issues include resource problems (over-exploitation of resources, waste of resources, etc.), environmental issues (air pollution, water contamination, etc.), ecological problems (loss of biodiversity, ecology damage, etc.), economic issues (imbalance of economic development, etc.) and social issues (uneven distribution of social resources, etc.) [5]. Based on the analyses performed in order to characterize relations between economy-ecology-environment, dynamics of resources using have a great importance for a metallurgical engineer. The coordination degree between the subsystems is directly influenced by interactions between the elements [5]. The normative

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foundation is the Integrative Concept of Sustainability (ICoS), which contrasts the conventional approach of sustainability which typically characterizes a sustainable future along the three dimensions of economy, environment and society [4]. Sustainable development is an ideological innovation, as well as being a rational development mode proposed after rethinking the uncoordinated development phenomena of the resources, environment, ecology, economy and society [5]. Product service system is one new production paradigm for manufacturing enterprises to cope with fierce market competition in service economy environment [2]. The continuous generation of waste causes serious environmental problems as it is disposed in landfills, because of its hazardous content. Sometimes there are wastes electrical and electronic equipment and they have important components that contain large quantities of non-ferrous metals and precious metals [3].

Some authors have studied in their works the most important aspects that prove of the role of natural resources for the system economy – ecology – environment [9].

The role of natural resources for the economical – ecological methods optimization is justified through reasons as:

• The resource directly provides utility flows to economic agents [1];

• Natural capital, under certain conditions, can be substituted with other forms of capital;

• Natural resources fulfill the *stock-support* function for economic inputs;

• So far as natural resources are not exhausted, they can compensate the negative effect of waste emissions into the environment; thus, they contribute to the maintaining of the environmental self-sustainability (also by self-recycling) [5].

The conversion of the statements made above into real operationalization instruments of environmental resources as dynamic factor of sustainable development requires laborious analyses, which will be further described in detail [1].

2. System analyses performed on the basis of the first law of thermodynamics

One can use following assumptions:

a. the Ist and IInd law of thermodynamics can be used in order to evaluate the relations between various economical – ecological parameters (indicators);

b. Concrete evaluations can be made by using as working instruments temperature, thermodynamic potential, enthalpy, entropy respectively negentropy (antientropy).

Papers on economic theory use the isochors or the free energy Helmholtz, F. As concerns metallurgy, where the quasi-totality of processes takes place at constant pressure, one has to use the isobar potential or the free enthalpy Gibbs, G [7].

Function of enthalpy H, temperature T and entropy S, the potential G variates through the range between two process levels or two quality stages of this process as follows: $\Delta G = \Delta H\text{-}T\Delta S$.

In nature, self – running processes (spontaneously), without energy consumption, are possible only if the thermodynamic potential decreases, reaching the null level in equilibrium state.

These processes are characterized by the inequation:

$$G_{final} - G_{initial} = \Delta G = (\Delta H\text{-}t\Delta S) \leq 0. \quad (1)$$

Inverse transformations, where G increases, are impossible under any condition.

The thermodynamic analysis of economy – environment systems can generate results as those presented further:

• Metallurgical processes cannot take place spontaneously, i.e. they are not self – running processes. For their running, a special condition is required, which is characterized by enthalpy consumption, so that $G_{final} > G_{initial}$ – G_{final} should correspond to the state of the product delivered for consumption;

• The increasing variation by enthalpy consumption, $\Delta G > 0$, can be measured energetically as concern the added value in the transformation process of the resource into a product for consumption. One can state, e.g., that for transforming an usual plate into an enameled one, the new added value can be evaluated through the difference between thermodynamic potentials of both states ($G_{enamelled\ plate} - G_{usual\ plate}$);

• $G_{initial}$ must involve also the energy quantum supposed by autofagy (self – consumption) processes required for the inferior quality resources capitalization;

• Complying with the Ist law of thermodynamics, no process ca run without wastes (material and energetic ones) released from its own boundaries into the environment. Due to this context, one proposes to analyze pollution (materials and energy transfer into the environment) as a process loss into the environment;

• Thus, pollution prevention and control are measures aiming at the minimization of waste release into the environment. One knows that there is no process without losses, therefore, projects like “plant with null wastes” are not justified even from the viewpoint of thermodynamics and such programs have to be interpreted as targets to be reached;

• Under such circumstances, one recommends applying technologies of wastes minimization.

The metallurgical technology with minimal wastes (TMPM) represents basically the totality of methodologies and means used in order to exploit as rational as possible the materials and energy resources, providing simultaneously the needs of the human society and the environmental protection. The evident difference between TMPM and a classical technology consists in reducing as much as it is possible from the technological point of view the amount of auxiliary materials. The TMPM elaboration, which makes references for each known boundary, is the most efficient instrument of preventing the secondary materials formation.

3. Systems theory used for the analysis of economical-ecological events

For a production stream, the simplest (primary) systemic structure is shown in Fig. 1:

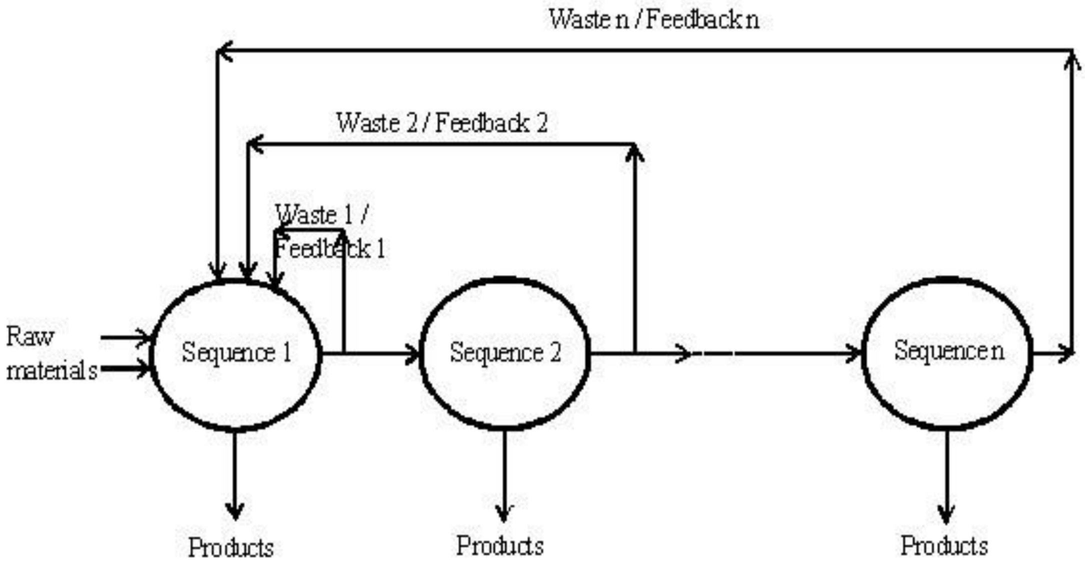

Fig.1. The primary systemic structure for production stream

• One proposes to characterize the pollution as running perturbation (disturbance) of the process system. Complying with the systems theory, a certain disturbance amount must exist for maintaining the order, because it provides information on state of the system;

• From the above mentioned one can deduce that for the “keeping alive” of the system, a certain amount of perturbation is necessary. Thus, one sustains that “null pollution” should not only be reached but that a certain pollution amount has to be kept on a necessary minimal level;

• One proposes to consider feed-back loops as support for re-circulated secondary materials;

• If recirculated secondary materials (wastes) are subjected to feed-back, they can have two functions:

a. Materials carry over (secondary materials resources – RMS) and energy carry over (secondary energy resources – RES);

b. Information carries over consisting preponderantly in technological deviations, which determined the occurrence of wastes; such information become instruments of system (self) regulation;

• Losses are irreversible; in the best case one can improve their valorization (recirculation) output; also from this point of view, the project “plant with null wastes” is not justified in thermodynamic limit;

• The volume of recirculated wastes on feed-back support depends on the value of inputs; these can be decreased by minimizing the raw materials, fuel and energy consumption. Thus, one contributes to the realization of an old dream of industrial producers: dematerialization and decarbonatation of fabrication streams.

4. Analysis based on the kinetic theory of processes

The analyses defined above can provide information about the sense a process can spontaneously run or the expenses required by supporting the process to run in an opposite sense.

In the case of production processes, the speed of event propagation is also of great importance. Under such circumstances, it is interesting to mention that “for modelling development strategies, not only the direction of phenomena propagation is important, but the historic evolution rhythm too” [6].

As concern the situation of metallurgy, one could observe that it is necessary to use enthalpy in order to change the sense of G. A similar measure is necessary also for economic-productive projects and processes which tend to run spontaneously in the required sense, but which naturally run at a very low speed and are not efficient from the economic point of view.

Information about the running speed of processes is provided by the kinetic theory of processes. This means that for the analysis of indicators as productivity, resources exploitation rate etc., one recommends to use analyses based on process kinetics.

5. Entropic analyses

This type of analysis uses the statements of the IInd law of thermodynamics.

• Entropy S is a measure of disorder (degree of randomness or chaos) as concern the organization of matter. The increase of S according to the decrease of G) characterizes the spontaneous tendency of systems towards chaos. Insulated physical systems are continuously subjected to the tendency of entropic decay, to chaos, which is a maximum one in the final state of natural equilibrium. Due to the exchange of matter, energy and substance, open systems, as production systems too, can organize their activity on negentropy direction, towards minimal levels of entropy. In such situations, the level of ordered organization can be evaluated using another physical quantity named negentropy or antientropy (nS).One can sustain that at a certain moment of the transformation (development), the system becomes a depositary of entropy.

• Resources (in this case, especially ores and fuels) are a form of ordered space arrangement of materials.

• The human activity is performed on two directions:

a. A positive, negentropy one (by substance, energy and information consumption), which increases the order, e.g., the extraction by concentration of minerals from ores, energy recovery etc.

b. A negative, entropic one, which decreases the order (increases the chaos), e.g., the consumption of resources with ordered environmental location and particularly, pollution:

• Pollution, evaluated as waste released into the environment, is an entropic phenomenon, which increases the natural disorder;

• Materials and energy released into the environment as pollutants are the more decayed the longer their distance from the source;

• The unavoidable consumption of natural resources is accompanied by the increase of the volume of pollutants returned to the environment and the occurrence of ecological imbalances. The qualitative and quantitative deterioration of the natural capital (implicitly of the environment) can be considered as a process consuming the negentropy stocked in the environment. In such a context, entropic analyses must be directed for the evaluation of natural capital sources which can be used on industrial scale as a stock of negentropy “extracted” from the primary entropic resources by applying technologies based on technical-scientific development. From this a point of view, technology reveals itself as a specific stock of negentropy [5].

• The aspect of a graphic illustrating the above mentioned could be the following in Fig. 2:

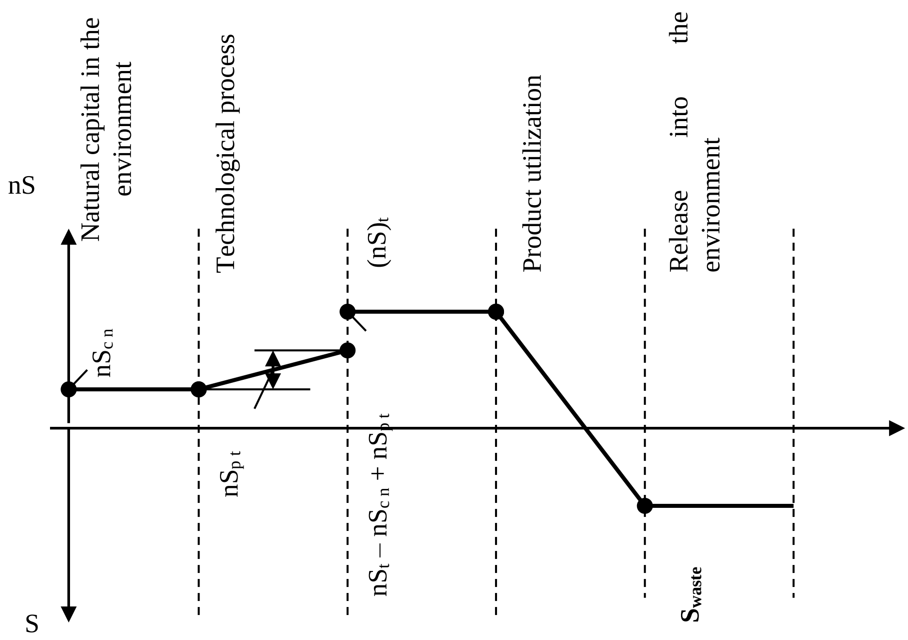

Fig.2. The correlation between the qualitative and quantitative deterioration of natural capital and negentropia deposited in the environment

As show the graphic, the self-sustainability required by a functional environment has to provide a negentropy reserve as relations:

$$nS)_t = (nS)_{c.n.}+(nS)_{p.t.} \quad (2)$$

$$(nS)_{e.e.} = (nS)_{t.}-(-Sw)=(nS)_t+(S)_w \quad (3)$$

where: $(nS)_{c.n}$ is negentropy which was initially extract from natural capital;

$(nS)_{p.t.}$ – negentropy which was realized by technological process;

$(nS)_{t.}$ – negentropy from the product on the market;

$(S)_{w.}$ – entropy from the scrap;

$(nS)_{e.e}$. – the whole negentropy that should be ensured by the environment.

• The adaptation capacity (self-sustainability) of the natural capital patrimony is directly proportional to the diversity of its constituents (in order to be responsible for the environmental “attacks”, a patrimony must be characterized by a superior variety as compared with it); under these circumstances, there is a clear evidence of the necessity to diversify the steel industry base of raw materials and energy;

• The not renewable natural capital reserves, even limited, are not absolutely exhaustible, especially taking into account the conservation of matter conservation law, they cannot be physically destroyed and can be partially recovered and recycled through adequate processing; the concept concerning available material resources, thus, has to be basically a dynamic one by the fact that “exhaustible” reserves cannot be considered a steady, immutable stock;

• As a result of the above mentioned one can draw following measures:

a. the higher the number of recycling processes, the lower the order of materials and energies; thus, one recommends *the decrease of recycling processes on a stream;*

b. the recycling within an aggregate (*inner recycling)* is superior to the *external recycling*;

c. Due to the increase of disorder with the distance from the metallurgical aggregate, it is recommended to perform the recovery as close as possible to the source.

6. Analysis based on the emergy concept

Due to the necessity for real energy consumption evaluation using a comprehensive, supreme, even absolute expression, biological ecologists, like Odum (1988), adopted the concept of emergy (derived from the English word combination: EMbodied enERGY) [5]. Under this category, Odum means the energy of superior quality, for which one uses as appraising currency the solar energy entering the system [10]. One appreciates, that by adopting this way of evaluation facts in metallurgy, one can launch the idea consisting in the possibility to quantify consumptions by help of this category of absolute energy, called emergy. Thus, one could be equivalent in a unitary mode, the efficiency of capital utilization for all the fields, whatever their nature (biological, industrial, economical ones etc.), that means one could make references regarding the efficiency of using the energy received on earth as solar radiation.

By weighting different forms of emergy consumed (or resulted) from a production process with the correspondent coefficients of the solar equivalent, one will obtain the emergetic equivalent.

It is possible to evaluate and to express on the same scale each transformation step of a system by determining the amount of emergy.

Under these circumstances, the performances of a real or simulated system are evaluated by emergy (energy of the same type) and not by effective energy, thus, one has to assess the concentration degree of energy as a ratio between the energy amount represented by the flux of solar origin while entering the system and the emergetic equivalent of energy which leaves the system (as products, wastes and so on) [6].

The emergy analysis is a precious instrument for the study of real processes, considering the energy as common denominator adequate to the evaluation of necessary and available resources, of economic costs, of environmental effects etc. [8]; the evaluation of the impact from various processes on the quality of life, of environment, is always an incomplete approximation if it is performed only based on production costs and benefits.

The emergy analysis can be used for all the three categories of energy inputs of a productive system:

• Direct energies, used in thermo energetic fabrication processes, transports;

• Indirect energies, viewing the production of goods, services, low publicity;

• Environmental energies, referring as well to the environmental energy contribution as to the services the environment offered to mankind for nothing.

7. Conclusions

Understanding the relationships of interdependence, as well as the differences between economy, ecology and resources is important from a scientific perspective.

The knowledge and applications of new types of analysis for phenomenon are based on thermodynamics rules, kinetics theory of industrial process, entropy and emergy theory for optimization of correlation from “economical – ecological – resources” field.

To conclude is necessary to mention:

- the need to assess energy consumption based on knowledge of emergy;
- evaluating self-sustainability opportunities based on the knowledge of the negentropy environmental components;
- expanding technologies with minimal waste.
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R E F E R E N C E S

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