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Energy and recycling forecasting. Part II. Resources for the secure life

Introduction

For the survival, we need to diminish the system plastic, fibres and biomaterial waste level and the use of our natural resources.

The purpose of this and previous work [*Flizikowski and Bieliński, 2014*] is the answer to the question: is the permanent energy and recycling development the basic requirements for future forecasting a goods and high processes effectiveness?

Resources for the secure life

Plastic, fibres, biomaterial and electronic waste, including printers (Fig. 1) that have reached the end of their usable life, should be recycled by specialized firms that have processes to ensure any data stored on those devices is not compromised and that are committed to recycle those devices in an environmentally and socially responsible manner .

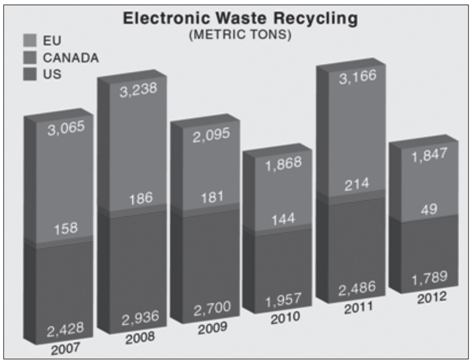

Fig. 1. Electronic waste recycling [*LEXMARK Waste Management, 2012*]

In 2011 in Europe more than 14.9 million Mg of polymer waste was methods of mechanical processing recycled, have undergone processes of combustion (Fig. 2), thermal energy recovery, which represents an increase of 6% compared to the year 2010 [*Global Energy Statistical Yearbook, 2012*]

As mentioned, we must not abuse our resources for the secure life of the users [*Cempel and Natke, 2002; Flizikowski, 2013; Bieliński and Flizikowski, 2013, Flizikowski and Bieliński, 2013; Flizikowski and Macko, 2013*]. Hence, for this end one may assume that the production subsystem input must be constant = N_o, due to the condition of the self-sustain-ability of our social system.

The input to the production subsystem is treated here in three possible ways in series; it is stored for future use as N_{us}, currently used by users, N_{uu}, and part of this, being in use and able to be recycled, is phased out as N_{up}. This is due to physical wear, technology change, economic wear, etc. The second part of this power $N_w = (1 - b)N_u$ goes outside the entire system, as processor waste, and it does not undergo recycling, as it has no ability to be recycled. We may call this the system lost power N_w. As is seen in this subsystem, there is only one power stream during the product distribution, sequentially delayed.

We can also treat N_w as the dissipative output from the entire technical system, not only from the distribution subsystem. In such a case the ageing energy accumulated, will be drained outside by this dissipative output N_w. Input energy to environment/the recycling subsystem consists of two parts here; it is the power corresponding to the phase-out from the distribution subsystem, N_{up}, and the power coming from the secondary recycling as the feedback enforced by the societal reaction to plastic, fibres and biomaterial waste, N_{sr}. Output from the recycling subsystem goes in the form of recycled power, N_r, to the production subsystem, and, of course, as the wasted power, not accepted for recycling, N_{una}. This may be due to the lack of direct recycling capacity, or organization of it, or the like. And this power, together with the power dissipated by the production subsystem, V (Fig. 2 in Part I), is the only source of plastic, fibres and biomaterial waste P of our environment-system.

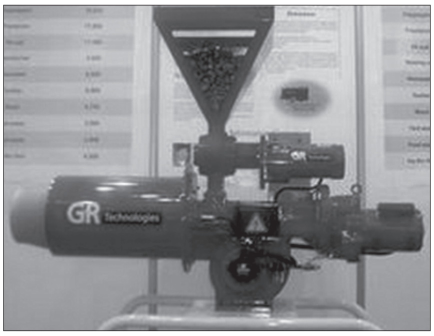

Fig. 2. Waste plastic burner: Combustion chamber: Burns PE or PP; PS & ABS require 50% barrel length increase. Rated capacity: 100,000 kcal/h on 9 kg/h with 11,500kcal/kg plastic fuel pellets. Plastic fuel feed rate range: 9÷15 kg/h. Current plastic fuel feed rate: 13 kg/h. Thermal efficiency: 75%; at 150°F water, thermal efficiency goes to 89%. Combustion chamber: 900÷1100°C. Boiler cut-in temperature: 60°C. Boiler cut-out temperature: 80°C. Boiler heating cycle: 5 h comprised of 2 h burning & 3 h circulating. Boiler heating rate: 1 ton water requires 45 minutes heating time (entire heating system will hold 3 tons water with 2 hours heating time). Power needs: 4 kW 110 vac with 208 vac for vacuum fuel supply. Future boiler: 2,000,000 kcal/h. [*Manufacturer: GR Technologies Company, Ltd., Seoul, Korea. Specifications for the PENN STATE Agricultural Program, 2009*]

Recycled power in this subsystem undergoes control by societal reaction, as the non-linear relation to the plastic, fibres and biomaterial waste level, P, ranging from zero up to its full capacity, N_{rc}.

Here the exponent of positive feedback was introduced to measure the rate of growth of the recycling power with respect to the increase in the system plastic, fibres and biomaterial waste level $P(\theta)$. Note also that the same plastic, fibres and biomaterial waste increase dP gives negative feedback to production subsystem by the exponent ξ, and the choice of both exponents will be decisive characteristics of the entire system/processor (Fig. 2).

This subsystem, where the plastic, fibres and biomaterial waste of all the processors is accumulated and its level $P(0)$ is measured for the subsequent control of the recycling. There are two inputs here, V and N_{na}, as the waste of the other two subsystems in operation, and also dependent on the plastic, fibres and biomaterial waste level. The control of secondary recycling N_{sr} is introduced and executed if plastic, fibres and biomaterial waste $P > P_o$ crosses the societal reaction level (threshold) P_o.

Such is the essence of the operation of the social system with production, recycling and secondary recycling, when societal reaction enforces it.

As seen from figure 1 (Part I), there is one known external stream of the input power N_i the system's feeding, and the main quantities for the analysis of the system behaviour are: production power, with its maximum capacity N_{uc}, and the recycling power N_r with its limit capacity N_{rc}. As can be seen, production diminishes when recycling is in operation, independently of the input power N_i. When the decrease of production power due to plastic, fibres and biomaterial waste is equivalent to the increase in the recycling power, we have $\mu = \xi$, and the simple linear case of plastic, fibres and biomaterial waste control.

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When recycling in a system is in full operation it may mean that the input power may be as small as the total efficiency of the technical system is high. If the natural recycling power capacity is assumed as infinite, as it was during the early stages of civilization, $N_{rc} \to \infty$ we simply have $(N_u / N_{uc}) = 1$; full production capacity can be utilized only at the start of the system, when the self-recycling of ecosystem is very large or infinite.

From this we can reach some design rule of the processor stating that if the total input of production module N_o equals full recycling capacity:

$$N_i + N_r = N_o = const = N_{rc} \tag{1}$$

we have:

$$\left(\frac{N_u}{N_{uc}}\right)^{\mu/\xi} = \frac{N_i}{N_{rc}} \tag{2}$$

and the production capacity ratio can be limited only by the energy and recycling capacity ratio.

When we analyses it a little deeper, one can infer as follows: if system goes to its full production capacity:

$$\left(\frac{N_u}{N_{uc}}\right) \to 1 \tag{3}$$

then the total phase out power from the distribution subsystem cannot be recycled totally: as $N_{na} \to b\, N_u$ with $b < 1$. This is the simplest expression for non-accepted power for recycling.

The same, the higher is the production capacity N_{uc}, and the lower is sensitivity to a plastic, fibres and biomaterial waste (ξ, the longer is EEP system life). Assuming that the system life time analysis is smaller than this value (θ_b), we can present the life time behavior of the upgraded power N_u.

The behavior of production power N_u also depends on its initial condition. When the production subsystem starts from its highest capacity $N_u(0) = N_{uc}$ it can only decrease during the system life time, adjusting itself to the recycling capacity.

We know from the production subsystem that: $0 < N_u < N_{uc}$, and we see that for the zero value of the production power we will have infinitive breakdown time, and from the other side if exchanging N_u for the saturation value N_{uc}. This serves also as confirmation of our earlier results.

As was said in the introduction, the whole idea of energy and recycling forecasting is based on three demands:

- to minimize plastic, fibres and biomaterial waste as much as possible;
- to minimize the amount of energy (resources) consumption; and
- to keep the production level as high as possible.

The first demand is not self-fulfilling and it needs proper adjustment between the production and recycling capacities, which can be done easily with the help of the above considerations.

The second demand, to diminish the input power of the whole system, can be fulfilled if constant input to the production subsystem is assumed, that means $N_i + N_r = N_o$ = const. In this case, recycling will fulfill its role entirely.

As (1 - b) quotient is the loss factor of our entire social system, we have here the first design rule of processor stationary operation. It follows that we can have a high production capacity N_{uc} to fulfill the demand of the forecasting system, only if the loss factor (1 – b) of the entire technical system is small. This depends mainly on the usage/ distribution subsystem, which should have the least possible dissipation of energy.

With a booming wind, bio-mass and a more renewable energy industry, the question is now arising of how to deal with end-of-life plastics, fibres and bio-material units, elements, turbines, and particularly the blades made of hard-to-recycle composites. This investigates possible routes for the recycling of wind turbine blades.

The global renewable energy and particularly the wind industry are growing fast, in terms of both the number of turbines and their sizes. Wind turbine blades typically consist of reinforcement fibres, such as glass fibres or carbon fibres; a plastic polymer, such as polyester or epoxy; sandwich core materials, PET or balsa wood; and bonded joints, coating (polyurethane), and lightning conductors. At the moment, there are three possible routes for dismantled units, elements, installations of renewable energy, particularly wind turbine blades: landfill, incineration or recycling.

The operation and regeneration reliability of energy and recycling technical potential $N^T(t)$ is defined out of the relation:

$$N^T(t) = \frac{T^T}{M^T(t)} \frac{\pi(t)}{\varepsilon^T} \tag{4}$$

T^T – number of technical potential appointed to operation,
$M^T(t)$ – number of technical potential taking part in operation,
ε^T – the theoretical technical potential possibilities,
$\pi^T(t)$ – the real creative possibilities and the level of technical potential responsibility.

The index of theoretical possibilities of reliable techniques of operation tends to one, if:

- the construction with its substantial scope includes also the destruction, $\varepsilon_k^T = 1$,
- the building, machine are constructed according to the construction, $\varepsilon_p^T = 1$
- use, operation, resistance, and durability are adequate, $\varepsilon_e^T = 1$ and $\varepsilon^T = \varepsilon_k \varepsilon_p^T \varepsilon_e^T \Rightarrow 1$

The real possibilities of operation and regeneration are measurable. Already known from literature are the values of the construction indices, products, and materials quality, the mathematical descriptions of operational states, and recirculation properties.

So far so good, but how does one assess the recycling capacity of technical system? Assuming a stationary case of processor operation, it means a stable level of plastic, fibres and biomaterial waste $P(\theta)$ (Fig. 1 in Part I), the recycling power N_r must be balanced by dissipated power from production subsystem V, and usage/ distribution subsystem N_{up}.

The smaller the energy loss during production, the more effective is the usage/distribution subsystem, the closer is recycling capacity N_{rc} to a production capacity N_{uc}, whatever it will he demanded by users.

Conclusions

As shown, it is possible to develop a simple forecasting model of power, energy, recycling flow and transformation in a users with environment, technical system, production and plastics waste, fibrous materials, biomaterials. The model itself is highly nonlinear, but its static and simplified dynamic analysis has shown that it is workable and can produce some conclusions about the interrelation between the environment-systems incorporated and the governing quantities.

In particular, it was find what kind of control and should introduce to design such a self-sustaining system. Some conclusions and design relations were obtained for the linearized version of the system equations, but it seems that the non-linear behavior of a system will also lead to similar results.

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