Chapter 9
Optimization and Sustainable Development

ABSTRACT

Optimization and sustainable development of energy systems are processes of creative activity related to the search for adequate values of material, machine, and process indicators with respect to the rational criteria. The mathematical product standard (quality), effective or non-effectiveness acting models of energy technical systems are conditions for optimization. Standard, as distance between two functions (function difference) – one of the functions usually describes benchmark (model), the second – real thing (matter, reality). In case of a energy processor, design features determined by the construction are the benchmark, while produced design elements of post-manufacturing forms and dimensions are the real thing (reality). The standard is usually calculated for the material and the machine and not so often for the process. The standard is at the same time the basic dimension (distance) of quality. Efficiency (relates to process, environment, and material), is dimension of all effects of creative activities of matter, energy, and information. The higher the level of recognition of processing and transformation needs, the smaller a contribution of undesirable effects to the achievable objectives of the activities. These optimizations occur in different construction sets and different ways of raw, waste, energy materials preparation, disintegrating, according to the properties of the material before and after the process. The behavior of the new disintegrated element (the cracking, bending, stretching, turning round, and/or the displacement of material) depends mainly on machine development, innovation, design-construction, and among other things, the shape of the working space and working tools (e.g. knives, hammers, balls, etc.) as well as on kinematic relations between such elements.

9.1. CONDITIONS FOR OPTIMIZATION

In such processes the unit energy consumption E_R of the process, as an amount of energy needed for grinding 1 kg of raw, waste or energy materials, is an important parameter connected energetically efficiency depends on the innovative construction of working systems and technologies taking into account the kind of material, the shape of the grinded elements and the expected average size of grains after shredding. The mathematical model of grinding is described as the dependence, where the material achieves the expected shape and dimensions necessary for further energy processing without

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any losing mechanical and useful properties of the product (*Bartodziej, & Tomaszewski, 2009; Boczar, 2007; Cegielski, 2009; Flizikowski, 2011; Flizikowski, & Bieliński, 2000; Lubośny, 2009; Kucowski, Laudyn, & Przekwas, 1997; Kopacek, 2007; Kasprzak, 2005; Jestin, 2004; Jabłoński, & Wnuk, 2009; Igliński, Buczkowski, & Cichosz, 2009; Hrynkiewicz, 2002; Macko, & Flizikowski, 2009; Macko, & Flizikowski, 2010; Marciniak, 2006; Mroziński, 2009a; Mroziński, 2009b; Mroziński, & Kikiewicz, 2007; Piasecka, 2011*).

The presented optimization methodologies, for the design-construction innovation, of grinders of the bio-materials and waste, require using several planes of modelling in order to use the knowledge bases for each area of application most effectively. This, in turn, offers a possibility for objective evaluation of the constructional design (working technical system) of any grinder from the point of view of minimal environment and energy expenditure. On the optimization research methodologies of grinding systems much attention has been paid to the range of loads, deformations, shifts and tensions of the waste. It was assumed, that an improvement in the functional characteristics can be achieved by introducing a programmed, state of stress in the milled element, which is most unfavourable from the point of view of waste-material durability.

The foundation of machine design and manufacturing process planning in the production of energy-materials is having the knowledge about the physical quantities of those substances. It concerns different groups of features, such as, physical, chemical, biological, and generally the technological. This is supposing that the ground element – during the grinding process – becomes an element of the machine, so it becomes subject to design criteria. Biological raw materials and bio-material waste, semi-manufactured products and final products, are environmentally active.

9.2. PRINCIPLE OF OPTIMIZATION

The constructive features and technology parameters of the grinding set of the energy-mills should be selected in such a way that the mathematical model or function achieves the maximal value (because of the e_R, indicator value) or minimal (because of the value of the unit energy consumption indicator E_R).

The point where the mathematical model or function value fulfils the required criterion is called the problem optimal solution: $x^* = (x^*_1, ..., x^*_n)$. The solution is, of course, from the permissible area:

$$x^* \in \Phi$$

The principle of the support in the direction of optimum getting the extreme solution can be defined:

$$\left\{X^* \in \phi\right\} : \left\{ \underset{x \in \phi}{\wedge} Z(x) \geq Z\left(X^*\right) \right\}, \tag{9.1}$$

in the case of minimisation of energy consumption ($Z=E_R$)

$$\left\{X^* \in \phi\right\} : \left\{ \underset{x \in \phi}{\wedge} Z(x) \leq Z\left(X^*\right) \right\} \tag{9.2}$$

in the case of maximisation of the effective milling indicator ($Z=e_R$).

The continuous growth of grinding systems complexity and the number of elements and relations between them results in the fact that the construction of states, useful characteristics, and contributing to the objects' transformations, in the environmental technological circulation, becomes a multi-layer problem, one which cannot be solved by means of intuition – without a rational mathematical model.

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