**10th International Research/Expert Conference**
**"Trends in the Development of Machinery and Associated Technology"**
**TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006**

# MODELLING AND DIAGNOSING OF LIFE CYCLE FOR MECHANICAL ENGINEERING PRODUCTION PROCESS

**Ružena Králiková**
**Alena Paulíková**
**Technical Univerity of Košice, Faculty of Mechanical Engineering**
**Park Komenského 5, 041 87 Košice**
**Slovakia**

## ABSTRACT
*Competing business challenges to interest in production process as determined factor for quality products, environment protection, production machinery condition, required parameters for machining and elaborateness for given accuracy. One of solution is the implementation modern simulating devices and applications of analogs in production practice.*
**Keywords:** LCA, process, production, simulation, analogs, model.

## 1. INTRODUCTION
It is necessary to pay attention to production process as a determined factor for product quality, environment protection, production machinery state, required parameters for machining and elaborateness, which is given for achievement of required accuracy. One of solution is implementation of modern simulation devices and application of models in production operation.

## 2. ENVIRONMENTAL MECHANICAL ENGINEERING STRATEGIES
Environmental aspects, its loading and protection give production enterprises the possibility of evaluation of their production methodology, used technology, raw material and energy management in term of environmental influence reduction. However, the quality of these solutions is depended on project quality for new building-up or reconstruction of production, there is needed to add ecological aspects to ordinary methods of projecting. The ecological ones in determined term ensure sustainable development of environment. Policy, economy and ecology have got significant function. Works, function and possibilities in environmental creation and protection is possible to outline in points which represent strategy of mechanical engineering development in environmental view at present:

- production of environmental suitable products,
- using of environmental acceptable technologies for their production,
- energy and raw material economy – low-waste, non-waste and recycling technologies,
- machinery and devices production for environmental protection and creation (water treatment plants, filters, separators, traps, eco-technology).

## 3. MODEL CREATION OF MECHANICAL ENGINEERING PRODUCTION PROCESS
Production process is the collection of human activity, machinery and physical processes and its results are particular kinds of products. At every production process there are three factors:

1. systematic activity – human work,
2. work objects which are transformed to products – basic mechanical engineering products are machines, function groups, nodal points and components,
3. means of work, which are production machines, devices, tools, accessories, helpers, transport and handling equipments, control technology.

During production process there are changed shape and composition materials so that the result is the new utility value. The production process can start if production factors, inputs are disposable. One of inputs can be also the creation of production process model. That is why is necessary to have concrete data, which characterize given production process. By analysing of process activity there are scheme where particular phases of phenomena observation or object perform these activities that are each other connected and regulated by producer's and customer's decision. In accordance to environmental view the mechanical engineering production process is open system with its relation to surroundings. It has got full interaction among subjects. In accordance to relations this system is quite open which makes possible the full interaction to surroundings, Figure 1.

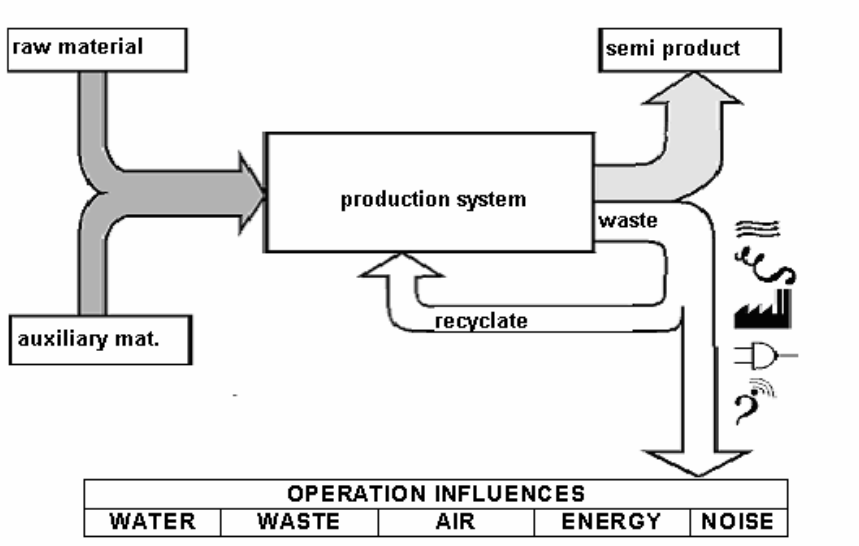


*Figure1: Production system environment*

Production process has also got its life cycle. There are characterized its production, system, technological and environmental phases. According to production aspects the process can be in beginning phase of its cycle. However according to environmental impact view can be out-of-date or according to qualitative parameters in leading countries "outsider". Working out of equivalent model of production process is has got several phases as followings:

1. **Prediction analysis:** Estimation of production running, its inputs and outputs is possible to make or by considering that production has got the same way eventually similar way or quite new and different way. The way is determined as kind of application, its evaluation, modification or change of production, systemic, technological and environmental approaches. It is important to establish the reliable obtained information. It can reach to use accurate methods of data collecting or application of measurement methods if there is an existing operation plant where it is possible to obtained parameters.
2. **Development of method:** According to number of inputs and outputs, we can choose strategy or methods for model development. We obtained various types of models with the combination of individual parameters. If we choose the main point as economical point and inputs will be reduced only gains, expenses, costs per hour, costs per piece, etc. Very simply model comes into existence but in real operation there is not applied. Many customers ask for quality, ecology, and modern technology not only low price.
3. **Model implementation:** There is a verification of prediction and correctness of used methods. If the preparation is worked out in detail then the implementation is simply and the model can be applied in short time. Implementation make possible to modify a model and it creates other opportunity to regulate and to adjust model.
4. **Control model:** After successful implementation of model there is finish period – i.e. control. It is the adjusting according to external and internal operational demands. All feedback relations in system can be used and following modifications, which do not influence the model creation but only they simulate all changes in production.

Model, which is created in this way, exists from its beginning to its finish and this model makes possible to eliminate or minimize mistakes. These mistakes would be developed directly in operation without the using of previous simulation. Model becomes the control tool for production process. Mistakes in model are cheaper than real production and changes, which are done in model, are reversible as well. Production enterprises cane use ***Model*** for improving or representation for customers, contact persons from state institutions, for certification of quality or environmental management, for training and courses of employees or for comparison of product quality to competing product. In model there are all accessible methods and technologies, which product operator requires. One of methods is LCA.

## 4. LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) is very often term predominately in environmental management field. Every mechanical engineering product shows environmental "track" in environment and this way these environmental impact are evaluated during all its life cycle – from the cradle to grave. It is complicated to obtain enough data number from operation. Or obtained data are different values, units or time and accuracy of obtaining.

Production process is also concerned hundreds of products and its characters are complicated. In LCA there are assessed for example harmful substances into the air and water, amount of solid waste as well, energy and raw material consumption, human environmental effects, ho are in production. Tools of LCA cover general matters as well as localizations independent from evaluation methods.

Modelling of process means the using of all available methods from LCA, SEM, standards ISO 14000 and 9000 and technological processes, CA technologies and likewise. Complex model can also simulate production accidents Fig.2

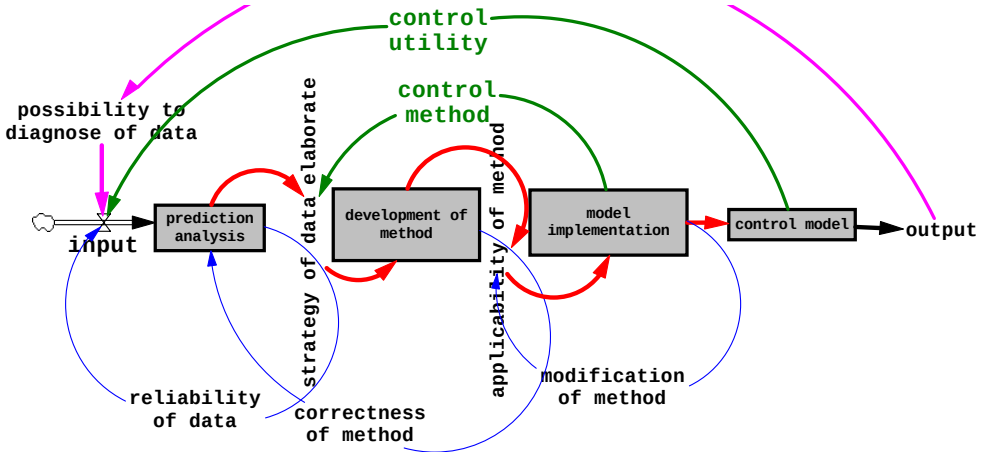


*Figure 2: Model operation steps according to program VENSIM*

## 5. MULTICRITERIAL ENVIRONMENTAL EVALUATION

This evaluation is based on quantification of parameters for environment quality by means of unbalanced evaluating effects of production process. Objectivity of solution have got number of evaluating indicator, their optimal number in interval 20-25. Deriving from following relations it is possible to determine $Q_j$ – value of environmental load:

$$Q_j = \sum_j \frac{a_{ij} - u_j}{s_j} \cdot k_j \qquad (1)$$

where: $Q_j$ - value of environmental load,

$a_{ij}$ - value j-element of vector,

$u_j$ – average value of j-element,

$s_j$ - standard deviation of modified j-descriptor,

$k_j$ - reduction constants.

Example for application of multicriterial evaluation in production operations:

**MULTIKRITERIAL EVALUATION OF PRODUCTION PROCESS**

| | | process criteria j | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | |
| | | number of produced pieces * (-1) has got positive relieving character | waste amount | failures | employees' average age * (-1) has got positive relieving character | accidents | electrical energy consumption | |
| | | [thousands] | [t/year] | [%] | [year] | [1/year] | [MW/year] | **Operation load $Q_i$** |
| Operation place i | 1 | **-100** | **4,2** | **7,1** | **-35** | **7** | **4,9** | 2,478178174 |
| | 2 | **-50** | **5,1** | **12,8** | **-41** | **4,** | **8,6** | 3,548164345 |
| | 3 | **-250** | **3,1** | **6,5** | **-38** | **3** | **7,4** | 0,133802099 |
| | 4 | **-90** | **6,3** | **8** | **-27** | **8** | **5,9** | 3,389464503 |
| | $n_j$ | -250 | 3,1 | 6,5 | -41 | 3 | 4,9 | |
| | $\bar{a}_j$ | -122,5 | 4,675 | 8,6 | -35,25 | 5,5 | 6,7 | |
| | $s_j$ | 75,95228765 | 1,175531795 | 2,482941804 | 5,214163404 | 2,061552813 | 1,412444689 | |
| coefficient correlation $r_{jl}$ ∈ (-1;1) | | • | $r_{12}$ = 0,766511893 | | | | | |
| | | • | ? | $r_{13}$=0,688018264 | | | | |
| | | • | ? | ? | $r_{14}$=0,130988332 | | | |
| | | • | ? | ? | ? | $r_{15}$=0,518905227 | | |
| | | • | ? | ? | ? | ? | $r_{16}$=-0,041946932 | |
| | | ? | • | $r_{23}$ = 0,413700665 | ? | ? | ? | |
| | | ? | • | ? | $r_{24}$=0,618941626 | ? | ? | |
| | | ? | • | ? | ? | $r_{25}$ = 0,686013732 | ? | |
| | | ? | • | ? | ? | ? | $r_{26}$ = -0,111420704 | |
| | | ? | ? | • | $r_{34}$ = -0,45765391 | ? | ? | |
| | | ? | ? | • | ? | $r_{35}$ = -0,234433807 | ? | |
| | | ? | ? | • | ? | ? | $r_{36}$ = 0,690757796 | |
| | | ? | ? | ? | • | $r_{45}$ = 0,8488946 | ? | |
| | | ? | ? | ? | • | ? | $r_{46}$ = -0,675518112 | |
| | | ? | ? | ? | ? | • | $r_{56}$ = -0,798467129 | |
| | | **reduction constant $k_j$ ∈ (0;1>** | | | | | | |
| | | $k_1$=1 | $k_2$=0,233488107 | $k_3$=0,182914685 | $k_4$=0,179594748 | $k_5$=0,017474471 | $k_6$=0,017215549 | |

It is obvious from application of multicriterial evaluation of operation that operation plant No. 2 is the most loaded. In spite of that fact there is the smallest production. Individual criteria are evaluated according to viewpoints. We multiplied for 1st and 4th criteria with coefficient (-1) in our case because these criteria have got "lightening" character of loading in operation plant.

## 6. CONCLUSIONS

Methods for diagnosis, monitoring and checking of technological, social and environmental aspects for production can have other applications. There are in small and medium enterprises for development of technology or optimalization of operation according to customer's, producer's or environmental engineer's demands. This period is period IT technologies and it could show that environmental pollution is slowing because operation plats of individual productions began to behave more understanding. It is true only in developed countries with strong environmental feeling. Model of life cycle for production process is one of tools that helps producers produce with optimal technology, develop products with optimal balanced performance and costs, characters which are up to standards for environment, health, safety and maintenance of sustainable development.

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