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THE METHODOLOGY FOR THE LOGISTICS SYSTEM SIMULATION MODEL DESIGN

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The present paper describes the methodology of the simulation model design applied in the analysis and parameter optimization of the large scale logistics system (LS) in metallurgy. The first part of the papers describes the method and steps of the simulation model design. The second part describes the analysis of the really complicated logistics system. Differences in large scale simulation model design are mainly in the obtaining of the data for individual elements model. Each element inside of LS has very complicated structure of the operations (blast furnaces, raw material stores, transport between mine and metallurgy). For the data obtaining have to perform detail analysis and research this individual elements.

Key words: simulation model, LS design, LS optimization, large metallurgy LS, simulation methodology

Metodologije za dizajniranje simulacijskog modela logističkih sustava. Članak opisuje metodologiju za dizajniranje simulacijskog modela primijenjenog kod analiza i optimizacije parametara u logističkom sustavu (LS) velikih razmjera u metalurgiji. Prvi dio rada opisuje metode i korake kod dizajniranja simulacijskog modela. Drugi dio opisuje analize kompliciranih logističkih sustava. Razlike kod dizajniranja različitih simulacijskih modela su uglavnom na prikupljanju podataka za pojedine elemente modela. Svaki element unutar logističkog sustava ima vrlo kompliciranu strukturu operacija (visoke peći, skladišta sirovine, prijevoz između rudnika i metalurških sustava). Za prikupljanje podataka potrebno je izvršiti detaljne analize i istraživanje pojedinačnih elemenata.

Ključne riječi: simulacijski model, projektiranje LS, optimizacija LS, LS velikih metalurških sustava, simulacijska metodologija

INTRODUCTION

The content of this paper is focused oriented on data obtaining for the modelling and simulation of the production, transport and stores processes in the metallurgy, which represents system approach of LS starting from the raw material resources through mining and metallurgy processes to the customers (automobile companies, cold roll mill factories, civil engineering industry, e.g.).

This large system can be considered as a LS, or logistics nets. For the research purposes this type of the system can be analyzed applying simulation models. In many cases the simulation (when parameter systems are stochastic) is only one possible solution.

The goal of this paper is to describing the methodology of the simulation model design and optimization of parameters LS applying simulation models. LS consists from elements which have very complicated structure. In the LS model this complicated units are represented as one element with its inputs and outputs. For information obtaining about each elements is necessary their depth analyses.

“This large system – originating its material flow from raw materials and moving towards end – customers we can understand as a logistics system or supply demand network” [1].

To obtain the data for the simulation model design and experimentation, it was necessary to analyze all processes in the chain as well as all divisions participating in the LS. The present research study describes case studies and models to analyze processes of mining, materials processing, metallurgical, transport, warehousing, maintenance, e.g. The result of case studies are data for the simulation model design, and input data file for the simulation model experimentation [2].

THE METHODOLOGY FOR LARGE LS SIMULATION MODEL DESIGN

The system can be analyzed and explored [3]:
a) on a real object
b) on a physical model
c) on a mathematical model
d) on a simulation model.

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The simulation is analysis and synthesis method, where the designed LS is replaced by its simulation model. On this simulation model are carried out experiments with the aim to achieve parameters that are later applied back on the examined and designed LS [4-5].

The simulation of a large LS is one of the latest and most expensive alternatives for the LS optimization. From the point of complexity, stochastic characters of operations the simulation is unique approach for the LS synthesis. *"Specific problem areas in steel production planning and scheduling include inventory management, slab, plate and cast design and melting shop, hot strip mill and finishing-line scheduling. Optimizing of each problem area independently can result in savings for a steel manufacturer. However, even greater gains can be achieved by simultaneously optimizing all of these interrelated areas."* [6].

Simulation models are functional models which simulate the functions, activities and processes of the real LS. In our case we are not modelling the real factory parts but its functions and processes, e.g. ore exploitation, storing, transport from underground, transportation of raw materials etc. The creation of a simulation model requires a specific analysis described during the simulation model creation [7].

In our case a large LS consists of discrete (transport of slabs, manipulation with coils, slabs) and continuous processes (iron and steel production, continue casting) [2]. For these types of the LS it is better to apply simulation systems which are able to model discrete and continuous processes, e.g. EXTEND.

STEPS OF SIMULATION MODEL SYNTHESIS

1. The problem definition is e.g. wrong function fulfilment; low performance of a shipping system, long waiting time at the crossings, violation of delivery dates, and overload of intermediate operation stores, etc. The problem definition is e.g. to find the optimal length of the green light at the crossing, the right place of allocation and the layout of the manufacturing system, the design of the optimal capacity of intermediate operation buffers, etc.
2. If the object (a company, crossing, conveyance system) exists, we have to define the system on this object, which we would like to optimize e.g.: a topology, element parameters, transmittance, and capacity utilization and to define the variables: time, position, and capacity. If a real system doesn't exist, we have to conclude it from its project and design. The meaning of the simulation model assumes the existence of projected system in a real or project form [4].
3. The definition of variables for the simulated model and capture of data, which described particular LS (operational time, transport time, waiting time, transmittance, capacity, etc). Provision of data for simulation model appears from results of analyses of each works in metallurgy factory.
4. The transformation of the defined LS into a bulk service system respectively or other formalized models which are in the form useful for modelling by a particular simulation tool (a simulation language or system).
5. The selection of a simulation tool – a system for the model creation. It can be – the universal language, e.g. Pascal, C++, however a creation of the simulation model is more complicated, or it could be one of block-oriented simulation languages e.g. GPSS, SIMAN, or one of iconic languages SIMFACTORY, EXTEND, which are necessary for the model creation. In these special simulation languages the model creation is significantly easier. There is the only disadvantage of the simulation model synthesis, the designer must be skilled in at least in one of the simulation languages or some other tools.
6. The creation of the general simulation model – is a concept of the simulation model and it defines which element of a real system will be modelled by which elements or tool of the simulation language, e.g. arrival of cars to the crossing will be modelled by generating random numbers in GPSS represented by the GENERATE block, in SIMANE by the CREATE block; the machine operation will be modelled in GPSS by orders:

   ```
   SEIZE      A
   ADVANCE    T1, T2
   RELEASE    A
   ```

   (A-name of machine, T_1-processing time, T_2-processing time dispersion).

   Such modelling will be carried out by different blocks in SIMFACTORY, and different blocks in SIMAN, EXTEND, etc. Steps 5 and 6 are the most creative. They are the core of the synthesis and require concise and creative way of thinking, knowledge of the object programming philosophy.
7. The creation of models of the elementary processes and the definition of parameters, functions and blocks:

   The parts of the model consist from elementary components – inputs, queue, machines, buffers, dividing, gathering, quality control, etc. Other parts of the model are:
   - the generation of random numbers (modelling of inputs, orders),
   - the process synchronization,
   - the time control in a simulation model (TIMER),
   - the gathering of the simulation results,
   - the output definitions – variables and their charts.

8. Transcribing of the model to simulation model using the language command – the creation of a simulation model (according to language type).
9. The verification of a simulation model:
   a) From a logistic point of view – if processes in the real system are performed in the same way as in the model, if model truly reproduces the behaviour and functions of the real system,
   b) From the formal point of view – if the syntax of the used language is ensured.

   While the logistical correctness must be controlled by particular controlling steps (e.g. model flows control, their directions and capacity), the formal point of view is controlled by a selected language compiler – simulation system.
10. The simulation time is the time that passes during model experiments. The essential question is how long it is required to simulate a real system so that results (executed statistically) can be approved as valid for a designed LS. Due to the complexity of LS relations, very often there is no possibility to define a simulation time. But the more precise results we want to achieve, the longer simulation time is required. There is one simple rule: the simulation is performed till $|x_i - x_{i+n}| \leq p$.

    This means, that the difference of variable x_i values during i experiments and $i + n$ experiments is less than or equal to the defined precision – p. If the required precision is achieved during experiments, the simulation can be finalized.
11. The evaluation and result calculation. From the results which offer the standard of simulation systems we can calculate some cumulative variables, e.g. total cost, calculation of multicriterial optimization.
12. Experiment iteration with another variant. One of the big advantages the synthesis by the simulation model is a possibility to simulate many variants.
13. Variant evaluation and selection of optimal solution. By some multicriterial evaluation of variants the optimal solution of the system is calculated. Simulation model makes possible to change input parameters as variation of parallel working equipments, variation of processing time. Variations of results are subject of multicriterial classifications. Target is to select optimal solution at clearly defined data.
14. Application of a solution to a real system.

THE TRANSFORMATION OF THE REAL LOGISTICS SYSTEM TO FORMALIZED MODEL

For the simulation model design of the LS we have to transform the real manufacturing, transport and storing processes to a formalized model as described above in the steps sequence of the simulation model synthesis [2].

This paper presents the case study (from the Slovak industry) and a formalized model of the LS from the Mine Siderit Nižná Slaná, s.r.o. (Figures 1, 2) → processing division Nižná Slaná → production of Fe pellets Nižná Slaná → transport to metallurgical company → reloading of raw materials and storing inputs, material stores → Fe production in three blast furnaces → Fe transport to steel works → continue casting works of the slabs → repairing hall and storing in the cold store → modelling of charging into the push furnaces → rolling on the wide hot rolling mill → and creation the tin coins → cutting workshop. Outputs of these processes are branches to three directions:

– customers,
– cutting division → customers,
– cold roll mill division.

Within the frame of the Mine Siderit Nižná Slaná research we concentrated on the balance model design of the production process and on the multicriterial optimization of applying reengineering methods.

For the purpose of production process analysis has to be created the next models within the frame of a metallurgical company it was mainly:

– the raw material discharging model,
– the layout of raw material optimization in the input raw materials stores,
– the blast furnaces charging model,
– the planning and scheduling models for individual aggregates,
– the models for indirect measurements,
– the products sequence optimization models for individual aggregates,
– the capacity models for the definition of the bottle neck of the metallurgical process.

Figure 1 and 2 displays a chart diagram of the formalized model LS in mine and metallurgy manufacturing processes described above.

The results of the analysis and case studies are data files for the design of a simulation model and experimental data for the simulation model of the LS.

Results of the analysis are the summary and aggregate data described in the chart diagram of the logistics system on Figure 1 and 2. The logistics system is described on the principle input → output for each elements of the complex modelled chain from raw material resources though individual technological, manufacturing, transport and storing processes to consumers.

The paper describes the result of research PROJECT NO RFSR - ST -2005 - 00046 SIMUSTEEL which is realized by the research team from the Logistics institute of production and transport of the F BERG TU Košice and the research team from the Production Department of the Faculty of Technology at University of Vaasa. Data which contain formalized model are obtained from case studies [2], [4], [5], [8], [9], [10], [11], and [12].

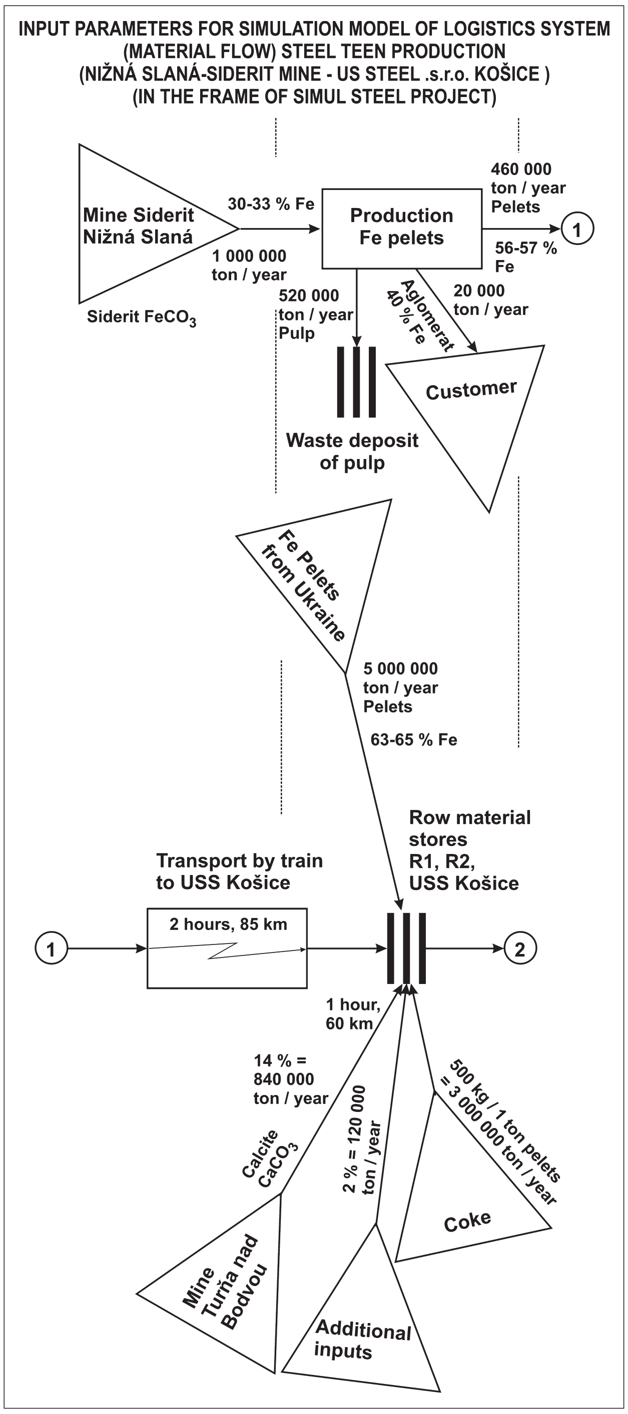

Figure 1 Formalized model LS, input parameters for simulation model of LS, part 1 [2]

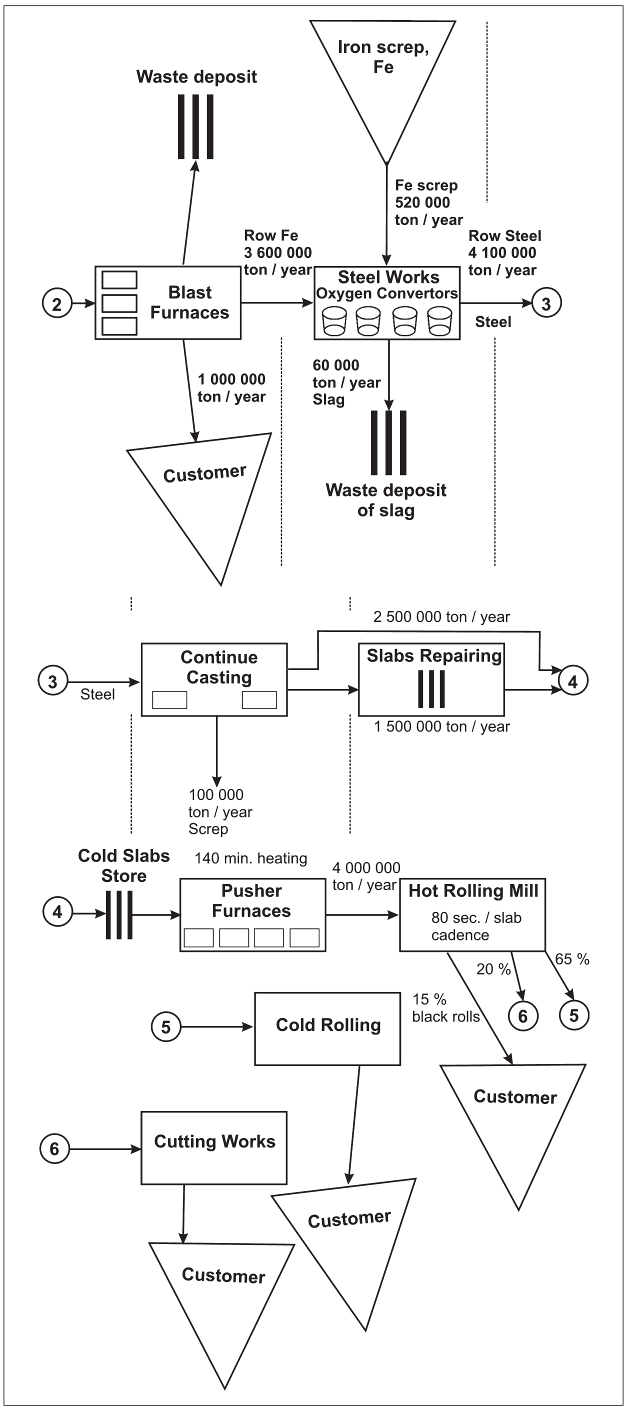

Figure 2 Formalized model LS, input parameters for simulation model of LS, part 2 [2]

CONCLUSION

The present paper describes the methodology of the creation of the simulation model which is in many cases only one way of analysing and designing the large scale LS. This methodology has been applied under the condition of the mining and metallurgy manufacturing [2], [13], [15-24]. The paper describes a formalized model and data which are necessary for the simulation model design and to perform the experiments with this model.

Described methodology was applied in many factories for example VSŽ – USS Košice, the Mine Nižná Slaná, the Mine Lubeník, Steelworks Podbrezová, the Mine Nováky, the Mine Veľký Krtíš.

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Note: Responsible for the English Language is the Lingua centre company in Košice.