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ABC SIMULATION USING DISCRETE EVENTS

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Abstract: *The current economic environment causes organizations to produce goods at competitive costs, given the careful monitoring of material and energy consumption and that of carbon emissions. In this context, Material Flow Cost Accounting (MFCA) has become the subject of the ISO 1405 quality standard. The present paper presents, starting from the mathematical model of Activity Based Costing (ABC), the design and running of the discrete-events simulation within the Anylogic environment. The results of the simulation are presented in an accessible form, respectively in EXCEL files.*

Key words: *Activity Based Costing, simulation, discrete events.*

1. Introduction

The current competitive environment requires the companies to be more and more efficient. In order to increase manufacturing efficiency, two apparently independent approaches have been developed: on one hand the Lean strategies, through focusing on identifying and minimizing activities with no added value, as well as by identifying system losses and eliminating them and on the other hand the IT tools for planning and controlling activities. The Lean 4.0 paradigm requires capitalizing on the benefits of both approaches [2]. In this framework, the author proposes the multi-objective optimization, respectively the definition of the objective functions for minimizing the consumption of materials, minimizing the energy consumed and for minimizing the carbon dioxide emissions.

The cost approach from the Material Flow Cost Accounting (MFCA) perspective is the cost calculation starting from the analysis of the sustainability attribute of the manufacturing process.

MFCA is regulated by ISO 14051 [7], which defines the three objectives of the MFCA (p. 4):

• increasing the transparency of the flow of materials and of the energy used, of the associated costs and of the environmental aspects;

• decision support for the organization for areas such as process engineering, production planning, quality control and supply chain management;

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• enhancing the coordination and the communication regarding the flows of material and energy within the organization.

The paper is organised as follow: the ABC methodology is presented descriptively and developed mathematically. The presentation is followed by a discrete-event simulation in Anylogic environment. The Anylogic software provides Excel tables with both the input and the output parameters. Also, the Anylogic module that is created allows graphical representations of the process parameters.

The application of the cost model by functions is analysed in the industrial context.

2. Simulation Model Design

In order to implement the simulation, modelling the entities of the real world is necessary. The simulation environments offer three modelling methods [6]:

• dynamic systems;
• discrete events;
• agent-based modelling.

Each method offers a specific range of levels of abstraction. The dynamic systems are used when strategic modelling is required, therefore a high degree of abstraction is involved. The modelling with discrete events is used when there is a low degree of abstraction. At the intermediate level there are agent-based models, which can provide various types of models from very detailed ones, where agents represent physical objects, to abstract ones, in which the agents represent companies.

The Monte Carlo (MC) method is defined as a set of procedures that allow solving a problem through statistical experiment/simulation. It performs the replacement of the values of the random variables with a finite set of values that have the same statistical properties. The analysis of the system is performed through simulation.

The application of the MC method requires solving two basic problems:

1. Establishing the distribution functions for the random variables considered when modelling the phenomenon.
2. Using a random numbers source.

Generating random numbers obtained by using the computer is impossible because it uses algorithms that cannot provide a zero correlation, but for most applications one can obtain pseudorandom numbers of a very good quality.

ABC modelling, implemented within the Anylogic environment [1], [8], will use the MC method. Two modules will be developed:

• activity Based Costing simulation;
• activity Based Costing analysis and optimization.

The application contains a shopfloor model, where the costs associated with processing the product are calculated and analysed using ABC. To each product are allocated certain resources, it is processed by a machine, it is transported and it releases the resources. Whenever the product is in the system, a cost share is applied. While a unit of resources is consumed by the product, the related cost is allocated to the product, otherwise the cost of inactivity applies.

Machine processing and transportation have direct fixed costs, which are different for equipment of different performances [3].

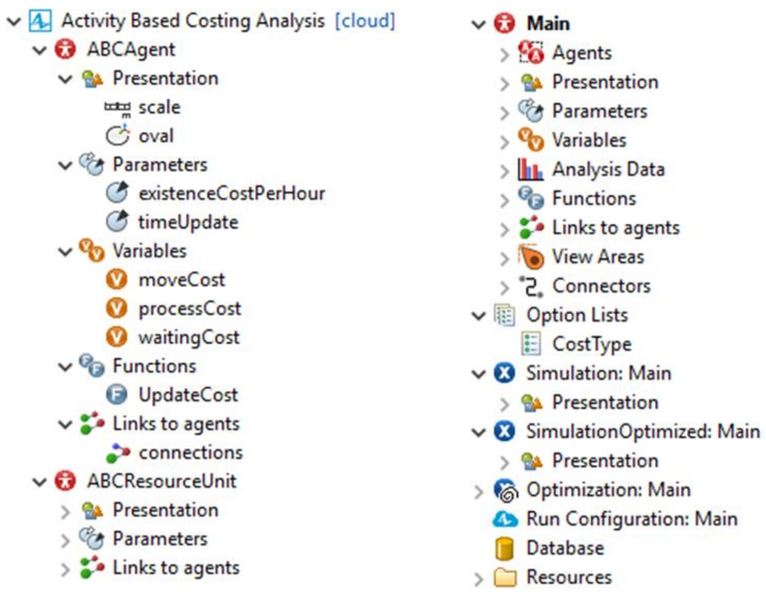

Fig. 1. *Agents, parameters and variables definition*

Figure 1 represents the design menu of the application. The two facilities will be developed starting from the previous model.

For analysis and optimization, the accumulated costs of the product are broken down into several categories. Shopfloor parameters can be set manually (Figure 2).

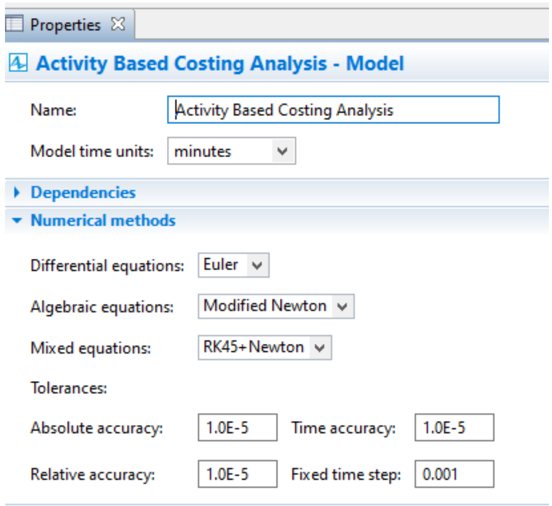

Fig. 2. *Choosing options for numerical methods*

According to Ivanov et al. ([3], p. 61), “Simulation is imitating the behaviour of one system with another”. In a simulation, cost in time can be observed and improved. By changing input parameters, the goal of the simulation is to understand the dynamics of costs.

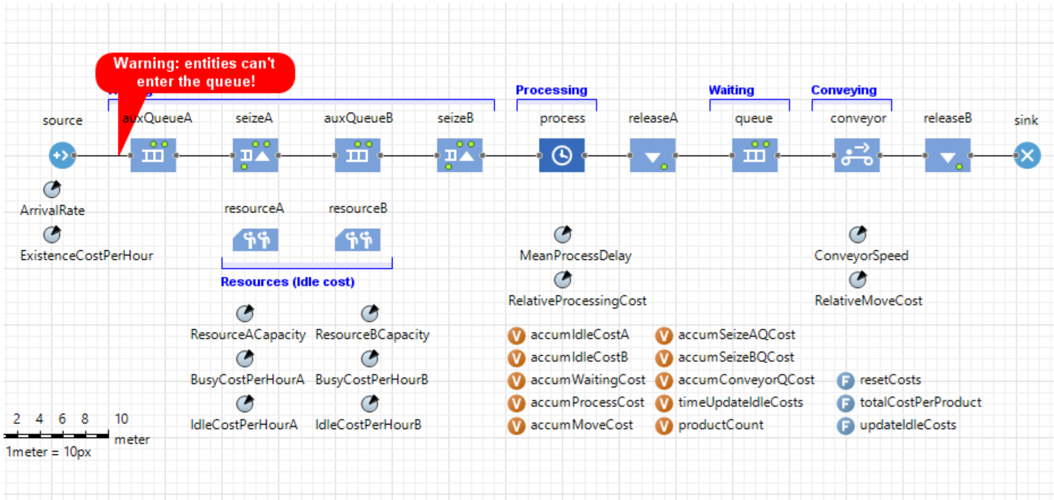

Fig. 3. *Manufacturing process modelling*

The three cost elements, respectively the movement, process and waiting costs are defined as system variables [4], [5]. The input parameters are represented by time and hourly cost. The definition of a specific function that performs the cost updating was provided in the design phase of the application.

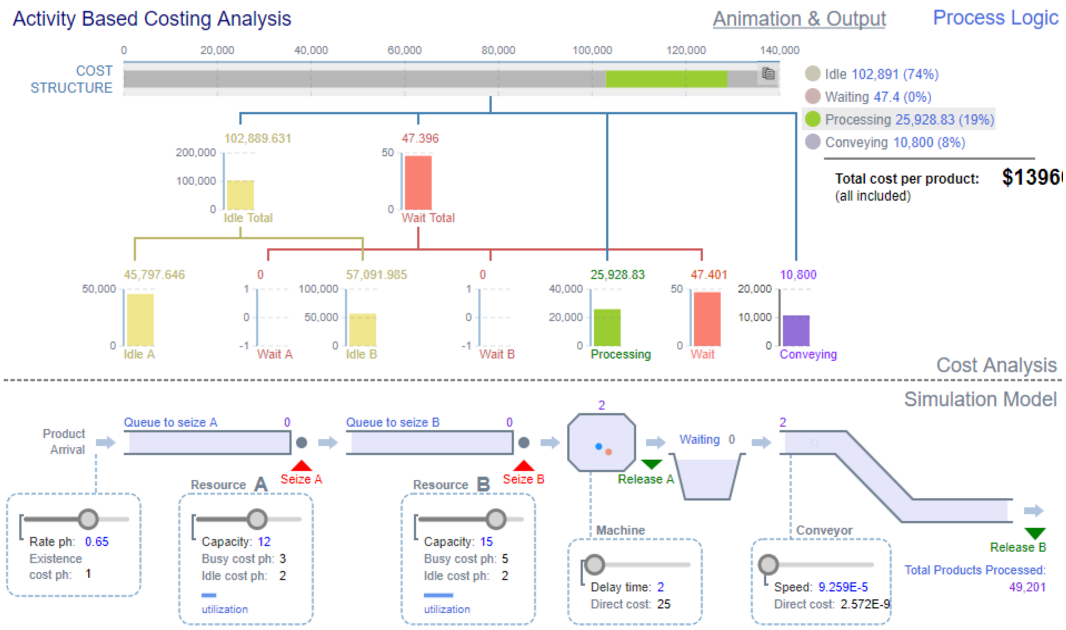

Fig. 4. *Running simulation - Animation-Output*

Figure 3 describes the definition of the model's specific properties, respectively the characteristics of the numerical methods that will be applied for the given system.

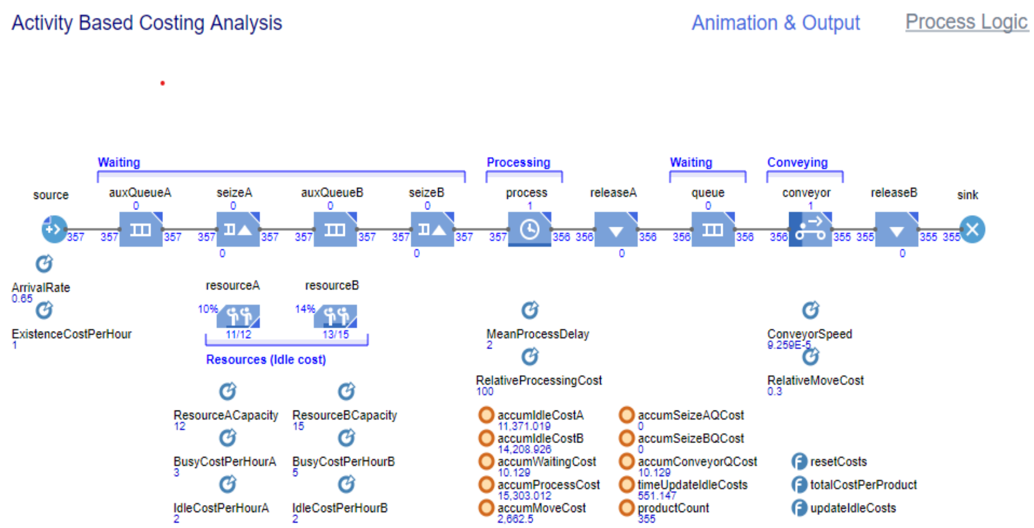

Fig. 5. *Running simulation - process*

The results of the process simulation are presented in Figure 4 (Animation) and Figure 5 (Process-running simulation)

As a result of the simulation, EXCEL files are generated in the analysis/optimization phase, files which contain information about the input and output parameters of the process.

Depending on the simulation options chosen, the output data will occur, which the system centralizes in EXCEL files. The resulting EXCEL file will contain the following information on cost structure and product status (Figure 6).

Cost structure

Name	Value
Idle	74.33
Waiting	0.024
Processing	43.04
Conveying	7.500

Product status

Name	Value
Idle Total	74.33
Total waiting state|Wait Total	0.024
Total processing state|Processing Total	43.04
Total conveying state|Conveying Total	7.50

Fig. 6. *Product cost structure*

3. Conclusion

By analysing the presented applications, it can be stated that the integration of the simulation in the design and the analysis of the value flow on the production chain allows the use of the information provided by ABC regarding:

• the possibility of choosing the most favourable option from several possible scenarios, without additional consumption of resources;

• visualizing the reaction of the system over time (it is possible to expand or temporarily compress it so that the observer can capture the details of the reaction of the system);

• the simulated model can be an instrument in itself, which can be used without the consumption of other resources, but only by connecting it to a different data set;

• the detailed analysis of the reaction of the system, which leads to a complete understanding of it;

• identification of system constraints, of the weak links in the value chain.

The optimization result is measured by using specific KPIs.

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