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Advantages and Problems Concerning Application of Simulations Trough Different Levels of Development Processes

Vorteile und Probleme der Anwendung von Simulation über mehrere Ebenen von Entwicklungsprozessen

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Abstract: Today's and future global market relationships require a new approach to the process of development not only of an individual product, but the whole production system which is, again, part of logistics network. Machines and technical systems are becoming more and more complex. The only way to stay competitive on today's market is to tend towards an optimization of all areas of activities. The consequence of these facts is larger usage of the modern software in all segments of development processes. Here problems of simulations will be analyzed all the way from demands and ideas to the final creation of a physical system. How can the real system be described by existing software tools? In two concrete examples the problems of transforming reality into the virtual model are analyzed and proposals given how to solve some problems, or, at least, how to improve some of their segments.

1 Introduction

Dynamic analysis of system parameters as real time functions, modelling extremely large and complex systems, analyzing system behaviour in extreme conditions, studying the behaviour of nonexistent systems etc. are all advantages of simulations. Iteration of simulations with different sets of parameters is the right path to system optimization. Their capabilities are great, but also limited, no matter if any classical program language or specialized software is used for this purpose. The outlet of simulations depends on quality of modelling, input data and software capabilities. The aim of this paper is to point out some of these problems which are springing in the application course of different types of simulations for complex development processes.

Time reserved for development and desig is shortened by every day. Stochastic, as the main characteristic of material flow, finds itself in a direct confrontation with grow of demands for speed and exactness that became an imperative of material flow optimization. As mentioned above, the use of simulation for the development or the redesign of logistic systems is a good approach to the philosophy of being „up to date“. That kind of approach has been administered by companies which want to preserve their current position, or to improve themselves by attaining a "right" position on the trade market, in "right"-time with a "right" quality of the provided service. For illustration of advantages and shortages of the said issue, two examples of software application are given in solving the engineering problems in the containers terminal of the river ports. The first example includes solving of goods flow, and the software used in this case is Enterprise Dynamics 7. The second example presents solving of the dynamics that appears when the container crane is in operation and for this purpose the software ADAMS (Automatic Dynamic Analysis of Mechanical Systems) is used.

2 Example of Material Flow Simulations – ED7

The first example is dealing with computer aided simulation of material flows in a river container terminal using high-value software. On the example of one port, in the conditions of expected amount of material flow and demands defined by location of the port, simulations are performed for the container terminal of 150x55m size. Here performances are studied of the models build with a means of different sets of accessible tools in the software and also their performance under different sets of variable values (input, output and system parameters). Comparison and studiousness of the simulation results is a basic layout for system design and further analyses on the lower levels of development of a new logistic system. Modelling and experimentation is done in the software Enterprise Dynamics 7. Relationships which exist between elements in the system could be quite complex and the quality of the model is limited firstly due to our apprehension of the real system. Existence of stochastic parameters doesn’t allow creation of exactly defined relationships, so it is only possible to define them according to some predictions. The practical problem that appeared during the building of the model was how to create these relationships and how to model multifunctional elements with available software tools. There are also problems that could appear only in the model and they are usually associated to the decision-making. For the mentioned example of a river container terminal several models were built. A container crane represents the main element of the system, and it was modelled in two ways. In the first case several elements (crane-atoms) were used, each for a different function, where activation of one element locked work of others. In the second case only one element was used, but it required combination of a number of controlling statements. Some parameters related to serving are: generally reloading of the barge had highest priority, one level lower priority had train reloading and lowest priority was assigned to truck reloading, but in the case of task combination (e. g. reloading directly from truck to barge) this order can be changed; loading had higher priority than unloading, but it was controlled via statement which again was dependant from arrival of containers in the terminal (unloading tasks).

It was shown that both methods gave similar results, but which one should be used depends mostly of the system variables which are observed. Figure 1 shows one 3D-model of the container terminal, and some results gained from simulation (simulated period was five working days).

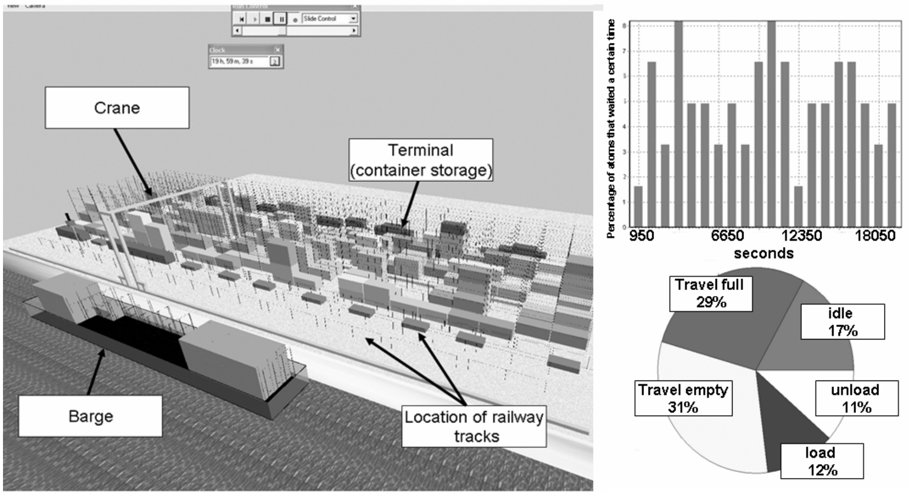
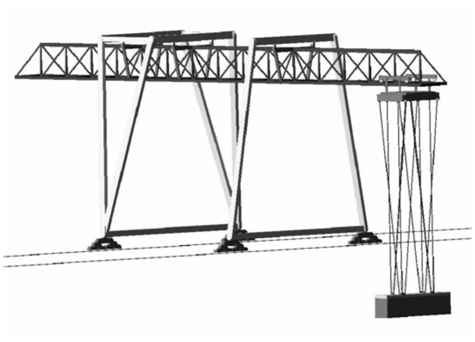


__Figure 1__: Container Terminal, Results (ED7): 3D Model of Terminal, Time Usage of the Crane and Waiting Time for Containers which Arrived by Train.

3 Dynamic Analysis of the Container Quay Crane

3.1 Software ADAMS, Accepted Crane's Construction

The second example includes simulation problems which refer to the adopted variant of the container quayside crane, which is the result of the material flow simulation inside the container terminal. The software used for dynamic analyses of the crane's steel structure is ADAMS (Automatic Dynamic Analysis of Mechanical Systems). In this example most of the advantages can be seen of computer aided simulations in comparison to any other classical method for studiousness of dynamic behaviour of mechanical systems. For the adopted terminal conception the container quayside crane has been designed, which has the technical parameters as shown in figure 2.

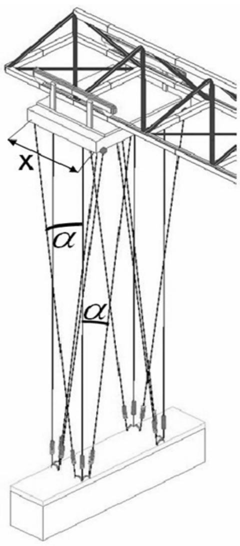


Span:	25 m
Outreach on both sides:	27, 5 m
Lifting height:	25m
Approximate weight:	290 t

__Figure 2__: Container Quayside Crane Model (Design in Software ADAMS)

3.2 Oscillating Periods, Control (Reason for Simulation)

A model of the container quay crane has been used for obtaining the oscillating period for different positions of ropes. With the shown simulation model it is possible to get conclusions which are needed for optimization in an early phase of planning and designing. For dynamic analysis of mechanical system there is need for solving a large number of differential equations which describe the observed system. This is not possible by usage of other classical methods. In figure 3 is presented the ropes' position in the model where the distance between ropes is marked with x and it is varied to see to what extent for different distances the container oscillating period will change . Both in plane of direction of trolley moving and in the plane of moving of the crane the ropes make the same angle α.



Results of simulation (value x is being varied):

Length ropes 15m, container 40t, and spreader 10t

Direction of trolley movement:

Distance x =5 m ⇒ T=2,51 s; a=485,63 mm

Distance x =6 m ⇒ T=2,15 s; a=335,39 mm

Distance x =7 m ⇒ T=1,93 s; a=233,21 mm

Direction of crane movement:

Distance x =5 m ⇒ T=3,45 s; a=207,93 mm

Distance x =6 m ⇒ T=2,97 s; a=172,93 mm

Distance x =7 m ⇒ T=2,68 s; a=147,71 mm

Figure 3*: Ropes Span and Position, Results of Simulation*

Practical application can be found in the correction period of swinging with modification ropes span, length and masses of container trolley and crane. In figure 3 with **T** the oscillation period is marked while with **a** the first amplitude is marked. As the ropes' lengths for different cycles are different, construction and ropes have their rigidness and damping, different mass of containers, simultaneous lifting up of container and moving of trolley and crane, the concrete values for control and acceptance of construction can be reached only by simulation. The equation which takes into consideration the masses of trolleys, crane and containers in calculation of oscillation period is:

$$T = 2\pi\sqrt{\frac{M}{M+m}\frac{l}{g}}$$

and this is an equation which is much closer than the mathematical pendulum. Where for case of moving in direction of trolley motion:

M- Trolley mass

m- Container mass

Or if it is a case of moving in direction of crane motion:

M- Trolley mass +crane mass

m- Container mass.

The question arises what happens when there are more ropes and when they are not vertical but under a certain angle. It is hard to define the real oscillating time due to many influential parameters, and because during the process the geometry is being changed. Therefore, the true oscillating period in an early phase of designing can be obtained only on the basis of simulation. Based on these results it is possible to choose adequate drive engines, which can achieve desired parameters. The global control method was used in the presented simulations (fig. 4). On the basis of observing the swaying time of containers in different operating cycles it is possible to define what would be the time of acceleration and braking for each operation cycle.

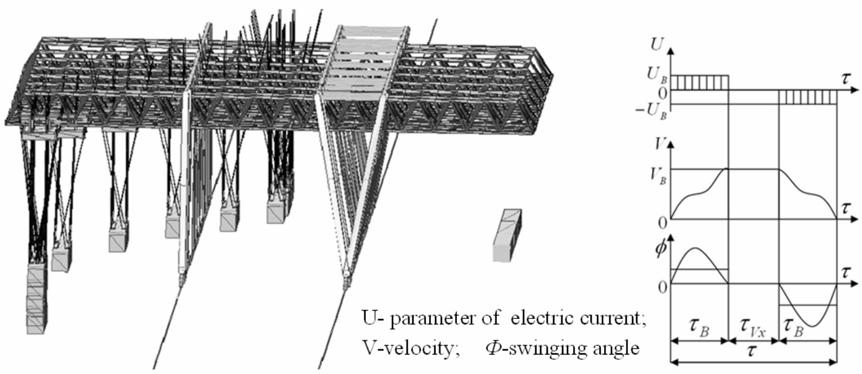


Figure 4: *Simulation (ADAMS) and Global Digital-adaptive Control System Siemens*

In figure 5 is depicted one such cycle and applied method – basis for control systems. From the figure 5 it is seen what time is needed to acquire the velocity of the trolley and the crane of 2m/s, provided to correspond to oscillation periods in both directions. As it is seen from diagrams the oscillation peaks in accelerating and braking are not equal and the reason for that is the change of the oscillating period in the course of lifting up of the container (i.e. moving of trolley and crane as well as lifting up of container were done simultaneously).

These are the assumptions of the simulation study:

- Crane velocity V_1=2m/s; Trolley velocity V_2=2m/s; Lifting velocity V_3=0,5m/s

- Trolley movement: Acceleration time t = 6,25s Braking time t = 3,3s; a_1 = 1332 mm; a_2 =245 mm (a_1- first amplitude for acceleration; a_2-first amplitude for brake)
- Crane movement: Acceleration time t = 8,3s Braking time t = 3,8s; a_1 = 906 mm; a_2 =350 mm

The results of the equation $T=2\pi((M*l)/(M+m)*g)^{1/2}$:

- Trolley movement: Acceleration time t = 6,28s; Braking time t = 4,9s;
- Crane movement: Acceleration time t = 8,28s; Braking time t = 6,4s;

The equation is not accepted for short ropes length (the influence of ropes position is larger).

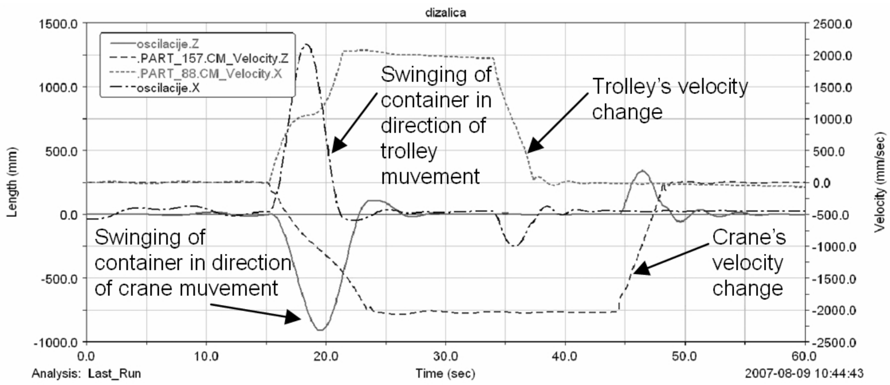


***Figure 5**: Container Oscillation with Corresponding Velocities of Trolley and Crane*

3.3 Calculation of Fatigue Based on Dynamics

On the basis of these simulations it is possible to determine which element is the most endangered and during which cycle. With these data about dynamics in every cycle it is possible to come to frequencies of stress for the most overloaded part of construction, and by that alone to come to the base for calculation of life time. This is the way for greater optimization of construction in the context of longer life time and the price during the early phase of designing.

3.4 Used Simplifications and Proposal of Solution

It should be emphasized that this model could not be made without some simplifications imposed by the software itself. The structure of the crane has been modelled as elastic with masses concentrated in parts. Elements of the steel construction are modelled as a combination of elastic elements (beams, which do not have own mass) and rigid parts of small length (part) which have own (equivalent) mass and most frequently appear on the connection points or on the most endangered areas. This kind of modelling produces differentiating of a model from the real physical model. Definition of the moving (displacement) can be done only between two rigid bodies, what is one of the basic problems accompanying work and simulation with ADAMS. So if we desire to analyze trolley movement alongside main girders this is limited to the quite short distance because discontinuity of the material in the model. Some proposals for overcoming these limitations will be presented in this paper. A problem is also the transition from one stiff element unto the other if it is necessary. By means of joints (translation, cylindrical...) which exist between two rigid parts it is not possible to adjust time-relation of the established joint between two rigid parts. Therefore, the idea appeared about the model the system by means of contact command, i. e. connection is established between trolley wheels and all rigid parts. It is clear that this is also approximation but in the manner it is presented in figure 6 it is possible to see that part which characterizes the steel construction saved its elasticity.

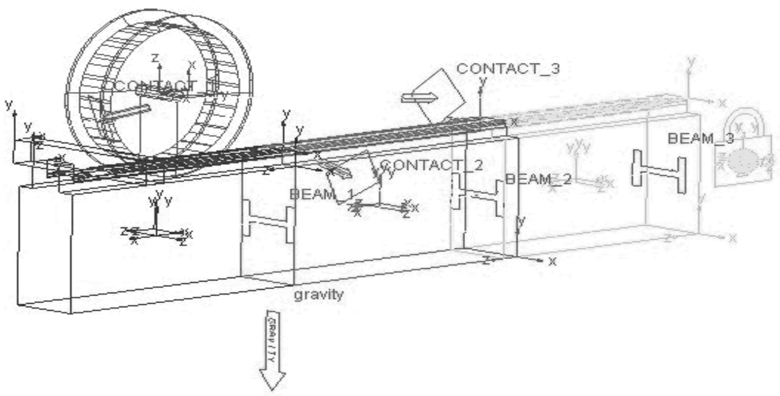


Figure 6: *Transiting from one to another Element (Command Contact)*

From figure 6 it is seen that elastic elements are interrelated, and transition and movement of wheels along the girder is enabled by means of rigid parts. Each element has elasticity, i. e. it is deformable but also contains a rigid part that serves for motion of wheels. This approximation imposes questions of local stresses. However, it is closer to reality from the previously made simulations. What also should be said is that the final results will depend on whether the constructor will be able and to what extent to apply and simulate the parameters alone. In figure 7 three examined models of contact are shown with an aim to define dynamics that will appear in the model. In every transit from one element to another some dynamics might appear in the model system that will not be presented in the true construction alone, but exists in the model only because it is not possible to make a more real simulation. However, this fictive dynamics is possible to be eliminated in a certain way (or reduced to a small value) from the model by introducing adequate parameters of contact. Software alone enables defining of a great number of parameters, and what should be in a certain way encouraged and emphasised to manufacturers of crane equipment is to give with their products the most possible data (for example, for ropes, engines, etc.). The more parameters of the model correspond to parameters that manufacturers give, the closer is the model to the real construction. The comparison of the simulation models with real constructions can give models and parameters which are, in total, acceptable from the design standpoint. Thus gained experience in an optimization aim can save a lot of money, which is greatly appreciated in present time and in the future.

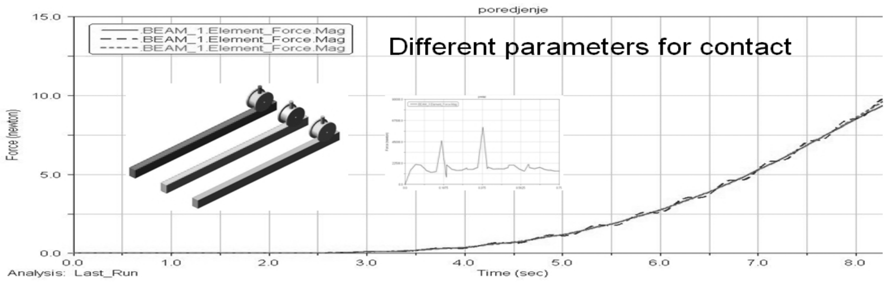


***Figure** 7: Testing of Different Variants of Parameters for the Command Contact*

In figure 7 in the upper diagram is seen that with the adequate contact command modelling the impact of fictive dynamics that will happen in transition from one element (combination of rigid and elastic parts) onto the other element can be diminished. To circumvent penalty sensitivity, ADAMS/Solver (FORTRAN) offers an augmented Lagrange solution technique. The method involves an iterative process to calculate the unknown contact force. For example, in the context of the POISSON force model, with k being the iteration counter, the augmented Lagrange iterations are:

$$F_n^{(k)} = \lambda^{(k)} + p\frac{dg}{dt} \; for \;\; k = 1,2,3....k_{\max} \qquad \text{with:}$$

$\lambda^{(1)} = 0$ for the first iteration, k=1

$\lambda^{(k)} = F_n^{(k-1)}$ for k>1

The distance between these two points is the penetration depth.

ADAMS/Solver then puts this distance into the formula:

F = K*(distance)^n; Where: K - material rigidness – exponent; F - force

In the calculation also take part both dynamic and static friction coefficients (μ_s is the coefficient of static friction, μ_d is the coefficient of dynamic friction). However, the core problem of the calculation itself, which is huge, will not be discussed in this paper. Some values that are necessary for calculation are obtained directly from the experiment for that characteristic case. With this approach it is possible to obtain data which are necessary in the early phase of designing and constructing, while with easy varying of parameters the most acceptable solutions are obtained.

4 Conclusion

The development of computers and software has enabled the system approach in the technical issues, where the simulations are a tool for optimization.

For most real problems concerning organisation of material flows the appliance of classical methods is mostly time consuming and sometimes even impossible. They are usually adequate only for simple cases. Whether the simulation is by usage of program language or high-value software packages, it can be said that simulation became every day need. On the example of container terminal it is shown that some applications of high-value software packages besides the existing problems have great possibilities.

In this paper the use of software ADAMS is presented for concrete solving of engineering problems, and the necessity in some cases of application of this software in some phases of design and construction.

ADAMS software has been for more than twenty years a superior for dynamic analysis and control of mechanical systems. Oscillation periods are presented in specific phases work for one container quay crane which is in the development phase, and because the obtained data are huge, only methods to obtain the solution are presented, but not the all data on disposal.

In spite of all presented simplifications used in creating the models, it is possible to eliminate some from the system on the basis of real knowledge of the process reality.

However, as some simplifications continued to happen in the model it is insisted that the model gets closer to the real constriction. In the paper proposals are presented which should help in getting the model more close to the real construction (system).

In contemporary modelling the need arose to get as many as possible parameters from the manufacturer, while for some parameters of the software some smaller experiments can also be used in order to confirm parameters of models which in similar cases can serve as the base for production of new models with which all their characteristics correspond to a real construction.

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