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ADAMS SIMULATIONS AS A BASE IN DESIGNING OF MODERN AUTOMATED CRANE

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Abstract

At the Faculty of Technical sciences in Novi Sad the users of ADAMS are the Institute of Mechanization (about 5 users)and that for research and design in heavy mechanization and motor vehicles. An older version is in use, while the replacement is expected with a new version with expanded possibilities for PC or VAX machines. I have been using ADAMS for some ten years in research of dynamics and automatization of cranes (preliminary concept development and design refinement).

Simulations of work of cranes using software ADAMS during research point out that one technical solution can be tested approximately in one day, by which in a short time the optima construction is achieved with accorded dynamics and elements for automation of operation (classic and fuzzy control methods are applied) since in this field there is no the prototype production and its testing.

In cooperation with MD GmbH it is expected to get the possibility to apply ADAMS also in specific demands of cranes, by which will be matched all demands in simulations of work and new quality of results achieved.

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1. INTRODUCTION

All research in the field of dynamics and simulation of work of cranes performed by the author in las ten years are linked to application of the software ADAMS, which is confirmed by a number of papers published in German journals and conferences held in European countries. During research were confirmed powers and advantages of ADAMS according to the knowledge of the author at that time a new field of application, and also were observed the points where by expanding of the software possibilities, a new quality in simulations of work of complex machines would be obtained with more simultaneous coordinated movements.

2. THE PROBLEM AND THE AIM

Cranes are machines which are constructed, for ports for instance, individually or in series of several pieces annually, so that they don't have a prototype for testing. These machines consist of metal frame-structure, drive mechanisms most frequently with electrical drives (can also be hydraulic drives) as actuators of motions and regulation elements with processors which control operation of the drive, in accordance to determined algorithms. The problem for the constructor is the dynamic adjustment of all elements of the machine, and that is one of the aims of research and simulations with ADAMS.

After the test and verification of algorithms in the control system, dynamic models are expanded in order to determine size of forces and torque moments in all significant points of the construction, by which the base is created for definitive application of FFT, FEM and CAD.

3. APPLICATION OF DYNAMIC ANALYSIS (SIMULATION) WITH ADAMS

The following examples illustrate the application of ADAMS for dynamic analysis, dynamic adjustment and test of regulation systems on several kinds of cranes with specific demands.

3.1. Portal jib cranes

In Figure 1 is given a graph of simulation course for one working cycles of the quay port jib crane which reload bulk cargoes. Through two combined motions and with processing guiding of the change of reach of the crane, the optimization of trajectory is achieved and anti-sway effect of the cargo which is hanging on the rope whose length is 20-40 m. With B are marked BEAM elements (matrix 12 x 12) and with CR the structural damping. In the Figure also is given the change of power in tensioned boom (cantilever) during simulation of work and that for the elastic model (Figure 1b) and for the stiff model (Figure 1c).

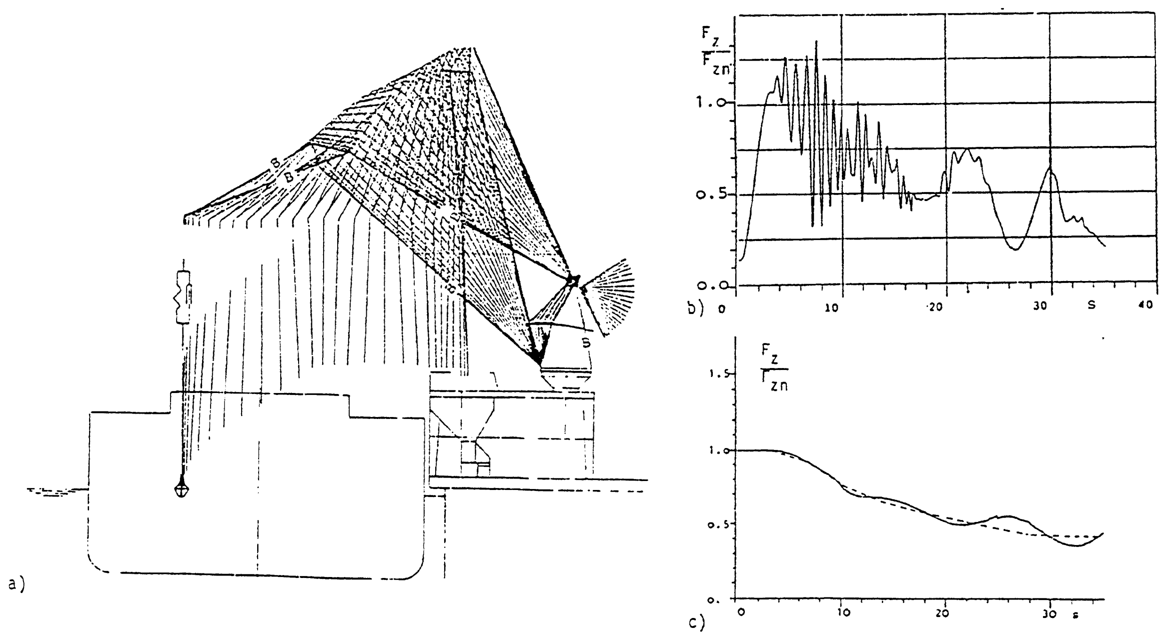

Figure 1: Dynamic model and graph of the simulation (a), change of force in the tensioned boom for the elastic model (b) and for the stiff model (c)

In Figure 2 is given a model of portal jib crane which is basically similar to the previous one but with more complex kinetics. In addition to motion of the port which can be working (for exp. for work in shipyards) or auxiliary (for exp. for work in harbours) the entire upper part is rotational on the portal. The change of the reach is conditioned by motion of gear lath(GL) or thread spindle. On the model over the elastic element and the force SF1 substitute the influence of counter-weight. The boom (cantilever) is elastic (B + CR) and the load is hanging on the elastic rope which is lifted up through a guide, at the same time that upper fit makes possible free swaying of the load in space. Since the horizontal position is required in moving of the load, in these cranes in change of the reach is regulated by pulley blocks. This work is modelled by means of elastic element tied with CO (coupler), so that the position of the upper fit of the rope for lifting of pulley blocks is a function of the angle of boom, that is reach. During the simulation with simultaneous two or even three working movements (always present correction movement meant to

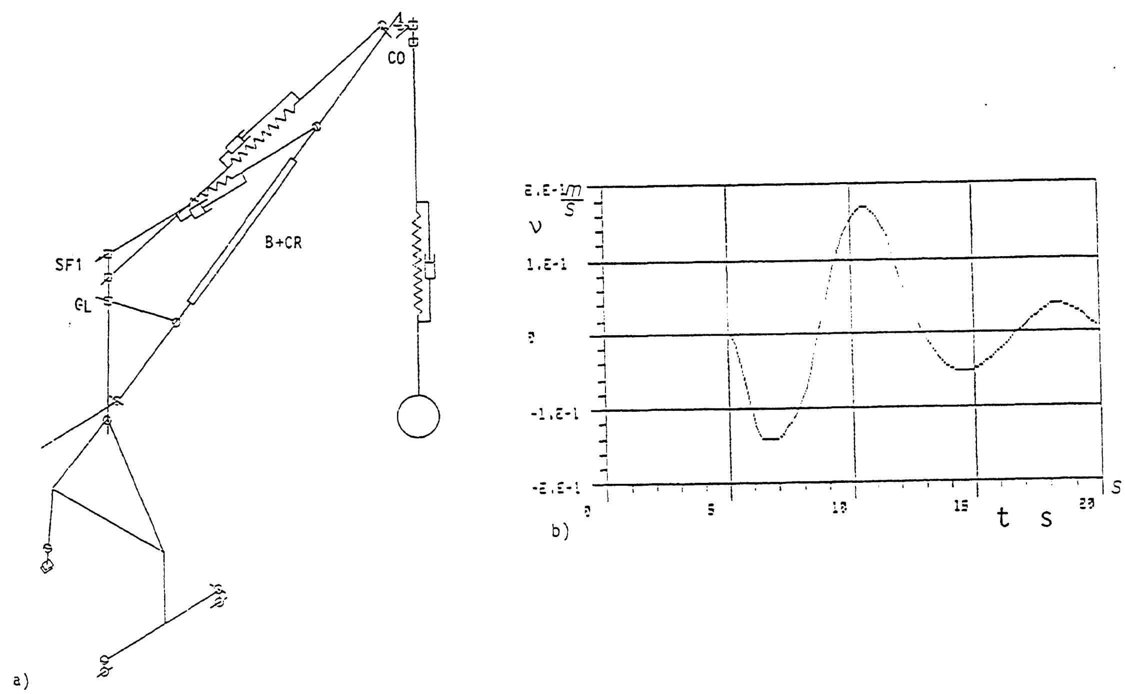

Figure 2. Model of portal rotation crane (a) and speed of cargo in relation to the boom top during simulation (b)

maintain horizontal position of the cargo at change of the reach) were observed sizes of dynamic loadings for various kinds of drive and regulation of the drive. In the same Figure (2b) is given a speed diagram of the load in relation to the boom top with application of reach for the case of by processor guided moving of the gear laths (GL), by which the anti-sway effect is achieved.

3.2. All terrain cranes

In Figure 3 is given a model of the rotating part of all terrain cranes with three telescope booms (Figure 3a) and corresponding ADAMS model for dynamic analysis with two or three simultaneous moving (B1 to B6 are BEAM elements with damping CR).

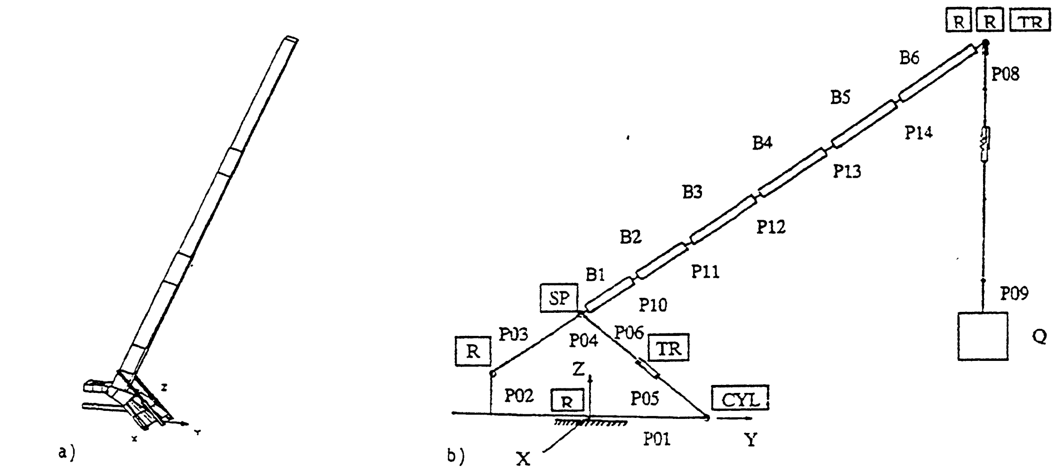

Figure 3. Rotating part of the all terrain crane

The elastic rope for lifting is movable in the upper fit (pulley blocks) which in relation to the boom top permits free oscillating in space.

3.3. Regal cranes

In Figure 4 is given model of the one-column regal crane where the parts of the construction (B + CR) are spatial BEAM elements with damping, and the rope for lifting is an elastic spring which has damping properties.

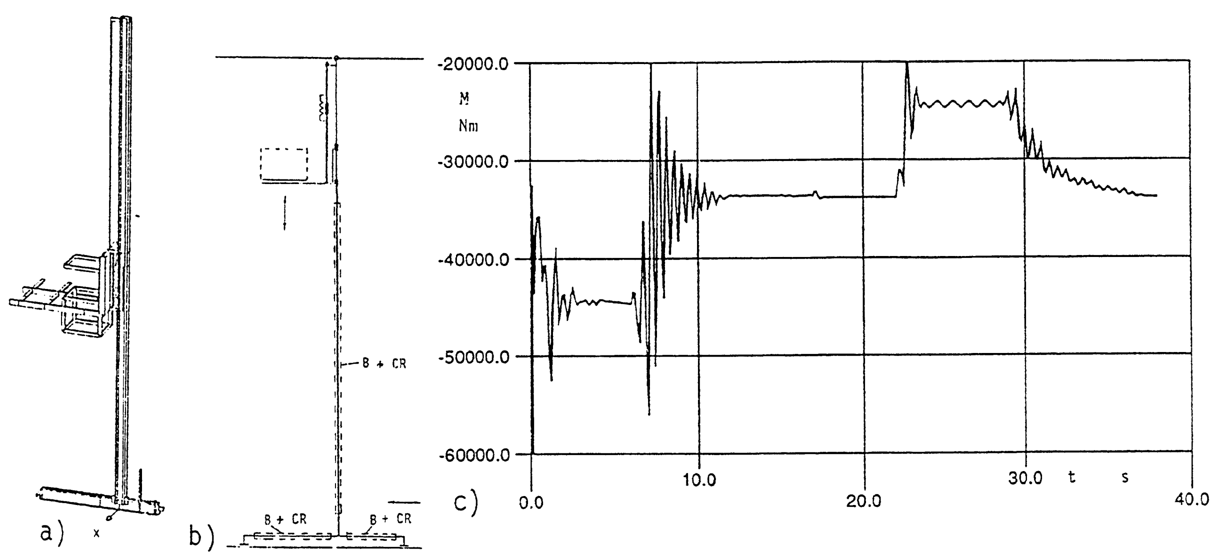

Figure 4. Model of regal crane: a) drawn by software KRASTA, b) dynamic model for ADAMS, c) change of the bending moment in connection point with the column and lower girder.

In the same Figure (c) is given a change of the bending moment of the column in connection point to the lower girder during simulation of one working cycles with two simultaneous movements.

3.4. Portal cranes

Research of the portal cranes include those ones for work in storage and in harbours and that both for general and bulk cargoes and for containers. In Figure 5 is given a model of portal cranes meant for test of the system of the automated control with three simultaneous movements (lifting and lovering of the cargo, trolley travel and portal).

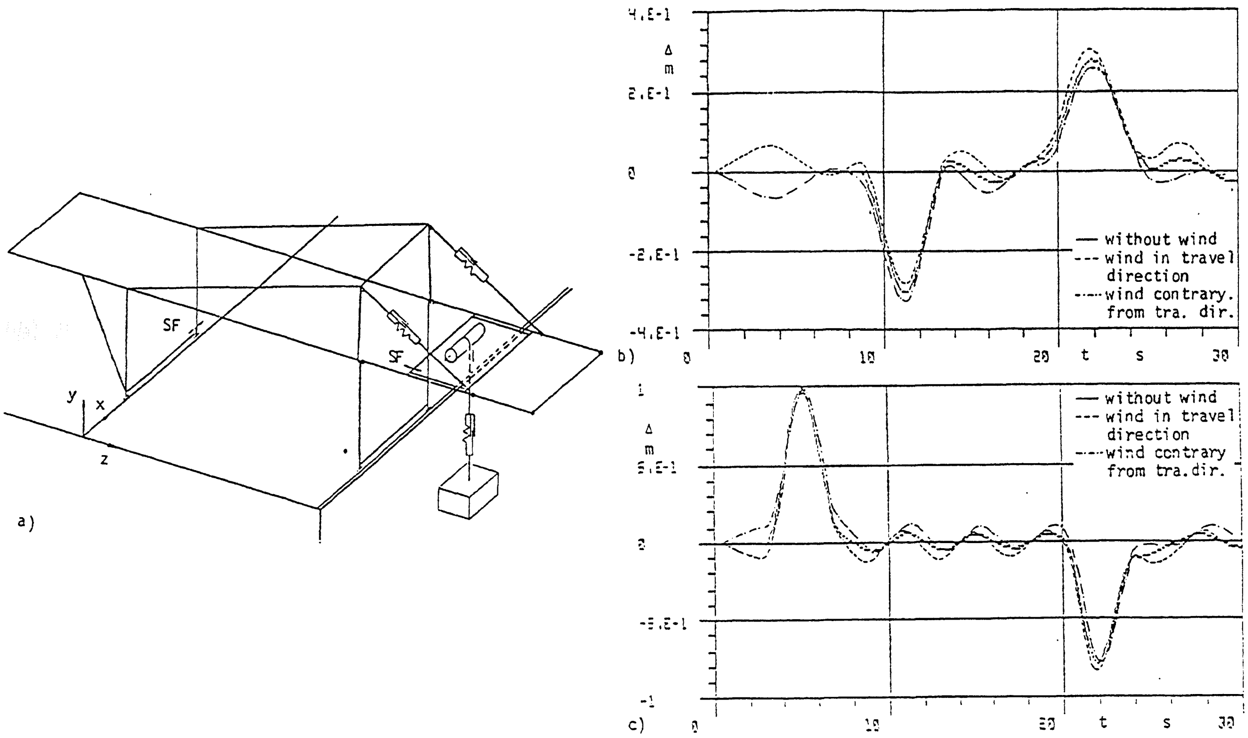

Figure 5. Model of a portal crane and diagrams of swaying of cargo in relation to trolley

During these simulations various conceptions of processor control of horizontal moving were tested (global digital and global adaptive method) for the trolley and portal, and that aimed to damp cargo sway and more accurate positioning before depositing the cargo. In the Figure are given diagrams of deviations (swaying) of the cargo in relation to the trolley (drum) during travel of the trolley (Δz) and portal (Δx), and with dotted line marks the influence of wind upon the sway and accuracy of the positioning. In Figure 6 is shown a model of the quay container crane with simulations which contain two simultaneous moving with optimization of trajectory and with processor guiding of the horizontal moving in order to damp sway of the container. Moving of the portal is a correction one. Container hangs on 4 elastic ropes which are lifted simultaneously, while the trolley are drawn with ropes upon which acts the drawing and control force SF. In the same Figure is given diagram of sway of the container during transport

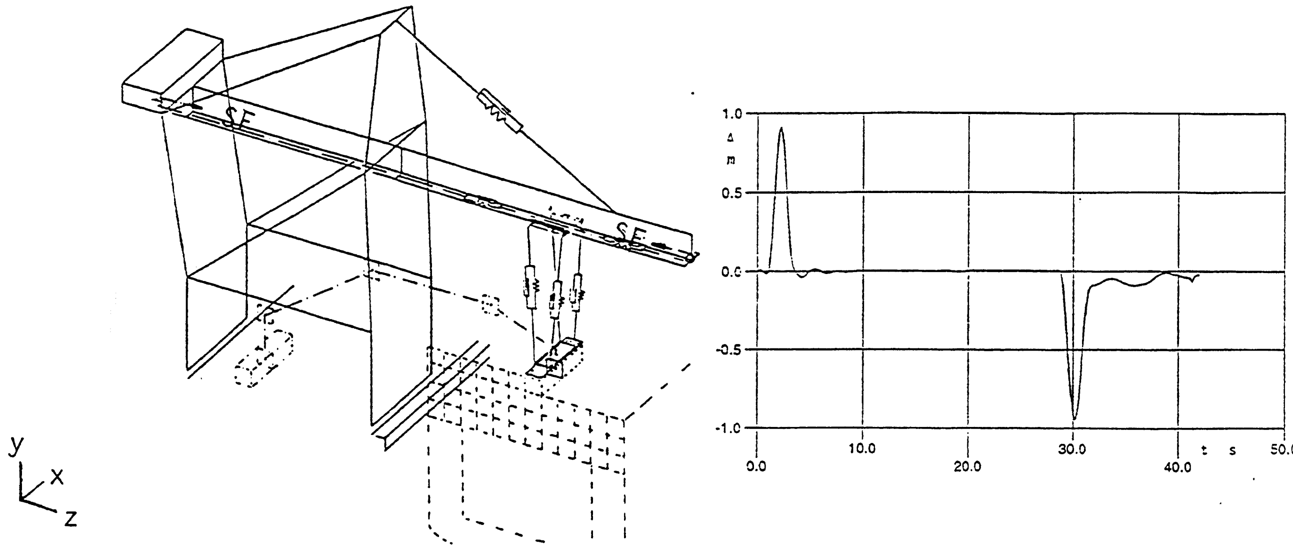

Figure 6. Model of a container crane and diagram of deflection of the container during reloading cycles

cycles where separateli is analized the proces of positoning considering the required accuracy of ± 5 cm (container's dimensions are 20 or 40 feet).

By simulations are tested influences of action of wind upon accuracy of positioning, as well as changes of position of the centre of the container and changes of the resistance in joints of the pulley blocks and ropes. From the research it results that required icreased accuracy of the positioning disappears even with small changes in work conditions, which points to a need and justification of application of Fuzzy concept of control for positioning of container automated cranes. Special advantage of the Fuzzy control method is a simpler control system with acceptance of real stochastic influences through an aspiration towards imitation of work of the best operator.

Given examples of various models of cranes are the part of the library of the programme for superior software which was supposed through dialogue to choose existing configurations of models, bring to them parameters of construction and drive and to call parts of ADAMS system. Due to financial problems this project has not been brought to an end, and the aim was to nearing of ADAMS to the projects in every day work.

4. LIMITATION ON USE OF ADAMS

During application of ADAMS u this field some problems have been observed which limit application or create problems in application, and generally can be solved within the existing conception.

In Figure 7 is given a structure of beam elastic girder along which the trolley travels. Due to dimensions of these girders, they should be elastic (BEAM), but the problem is how to change lengths of BEAM elements by travel of trolley at each step of integration.

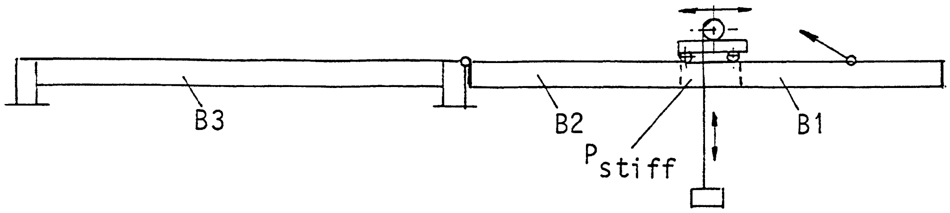

Figure 7: Travel of trolley along the elastic beam and transition from one into another section

However, BEAM elements can also be FIELD elements with length as a variable. Under the trolley can be stiff PART of a constant length whose position is between B1 and B2 variable.

Also is a problem of transition of one elastic element into other field (B3) and continuation of moving in this field with a new variable zones (B3 and B4).

The problem of continually distributed own masses is also present in a dynamic system, but it is moderated with a number of reduced masses.

5. CONCLUSION

The advantages of ADAMS for the analysis of dynamic processes in case of crane machines with more simultaneous moving in which for all transient processes is required a processor guidance in order to make positioning are original. Given examples whose model conception is dependent on requirements and purpose contained between 300 and 1000 equations for a crane analysis of elastic system, which approaches model simulations to real work conditions.

Possibility of interactive work of a constructor in bureaus with libraries of prepared models, would introduce ADAMS into everyday use in design.

Also, possible corrections in configuration of ADAMS would make possible use even in those cases where it, up to present day, has been impossible or difficult (for ins. travel of a trolley along the elastic beam).

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Key words: ADAMS, CRANE, DYNAMIC, SIMULATION