Multibody Systems – approaches and challenges

The multibody approach for the mechanical problems is a new one and it is based on a few aspects: determination of all constraints applied to the system; the written of the matrix of constraints for each body; determination of the kinetic and potential energy for the mechanical system; the obtaining of the matrix differential equation of motion; the solving of the non-linear differential system. The written of the equations of motion implies the introduction of the column matrices of the Lagrange multipliers; these multipliers can be hardly eliminated from the equations of motion. The methods for this elimination presented in the literature, base on the assumption that the so called matrix of inertia is an invertible one, which is not always true. Scientists created different algorithms which select the complete rank sub-matrix from the matrix of inertia. Another problem is that of the complexity of the equations of motion, equations obtained by applying the Lagrange second order equations. There exist some main directions of study: the obtaining of the equations of motion starting from other expressions given by Kane's equations, Maggi's equations, Appel's equations, fractional calculus etc.; the introduction of some pseudo-coordinates (fake coordinates) which simplify the form of the equations of motion, but having the disadvantage that the equations of motion are no longer independent; the selection of other parameters as generalized coordinates, method which is particularly applied in the case of mechanisms etc. The advantage of such method is a relative one, that is this advantage exists only for some particular mechanical systems (presented as examples in the literature); these methods may be very toilsome for other mechanical systems. The selection of the method is up to every scientist.

Increasing the number of bodies in the system leads to the increasing of the number of equations from which one has to determine the motion of the system. Any new rigid solid with constrained motion introduces minimum seven new equations (the case of a single constraint) and maximum eleven new equations (the case of five independent constraints). Moreover, it is possible that the system admits only certain motions, fact that leads to the apparition of the redundant equations. Another aspect is the fact that some bodies in the system may be rigid solids, while others one may be deformable. Generally, the analysis of such a system assumes the application of the finite element method, the boundary element method etc. leading to a huge time of simulation for the determination of the system's behavior. The constraints of the system may be bilateral or unilateral ones.

The problem of the determination of the equilibrium positions still remains an open one, while the numerical methods used to solve the problem have the disadvantage of a convergence limited to a particular domain (generally, a small one) around the solution. Moreover, the system may lead to the existence of many equilibrium positions, the number of them being impossible to be a priori determined. For some particular systems the scientists observed the boundedness of the solutions for a part of the parameters that determine the motion. This thing has two immediate consequences: relative to the initial conditions of such a system and the behavior of the system when the initial conditions change. For a single body it is relatively simple to determine if the constraints are or are not independent. In the case of a system composed by many bodies the situation is more complicate.

The numerical methods used for the study may easily lead to divergent solutions; hence one has to apply periodical corrections of the solutions with complications of the calculations programs and increasing of the simulation time. The clearances in the mechanisms are modeled either by unilateral constraints, or by the introduction of a new elastic element; the last variant may lead to the singularities in the mechanism's behavior. The control of the mechanical system (e. g. in which conditions the motion of a certain body has some particular characteristics (periodicity, is an imposed one etc.) remains an open one. For the systems consisting in a small number of bodies with simple constraints, this kind of problems is, generally, solved. In conclusion, the field of multibody systems is a domain with numerous future directions of research.

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