Forth Serbian (29th Yu) Congress on Theoretical and Applied Mechanics
Vrnjačka Banja, Serbia, 4-7 June 2013

CONSTRAINT REACTIONS IN OPTIMAL CONTROL OF MECHANICAL SYSTEMS

J. Vuković[1], A. Obradović[1]

[1] Faculty of Mechanical Engineering,
The University of Belgrade, Kraljice Marije 16, 11120 Belgrade 35
e-mail: aobradovic@mas.bg.ac.rs

ABSTRACT. This paper is dedicated to the establishment of a general procedure of forming the optimal control problem of variable-mass nonholonomic rheonomic mechanical systems, where reactions of constraints are present in differential equations of motion. Dimensions and structure of a configuration space depend on the number of reactions of constraints that are the subject of our interest, i.e. only the reactions whose magnitudes are subjected to limitations are considered. In this paper, the procedure enables the direct application of Pontryagin's maximum principle for the systems with limited state. Attention is particularly focused on discussing various modes of realizing control by combining active control forces and subsequently imposed ideal holonomic mechanical constraints. Brachistochronic motions play an important role in this type of problems, because in those problems control by motion can be always realized exclusively with ideal constraints. The paper provides three examples of this method application, which are related to the realization of the brachistochronic motion of mechanical systems. The first example [1] considers a nonholonomic rheonomic mechanical system. Two modes are presented, control by active forces and without the action of active forces. The second example refers to a variable-mass system [2], where motion is carried out exclusively by the constraints that are, in this case, realized by the rolling of a moving centroid along a fixed one. The third example represents the case when the reaction of nonholonomic constraint is limited in the brachostochronic motion of the Chaplygin sleigh [3]. In optimal motion the reaction of a blade is, in a segment of the motion interval, on its boundary. Here, the motion is also realized by the imposition of an additional ideal holonomic constraint.

Keywords: optimal control, Pontryagin's principle, limited constraint reactions, nonholonomic, scleronomic, variable mass, brachistochrone

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