Application of Two Tension Springs in the Four-Bar Engine Hood Linkage Mechanism

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ABSTRACT

1 Introduction

The concept of designing mechanisms with various considerations, such as developing a four-bar linkage for kinematic and dynamic analysis, is not new. The typical process begins with determining the dimensions of the linkages, followed by optimization for various factors, including dynamic and kinematic considerations [1, 2]. Research commonly adheres to a two-step process: first, the synthesis of the mechanism, and then the modification of its components based on specific considerations. This traditional research framework has been the bases for numerous studies in mechanism design [3-7].

Previous studies have introduced four-bar automotive engine hood linkage mechanism loaded with tension and torsion springs, employing a conventional research methodology [8, 9]. Subsequently, a novel one-step procedure integrating kinetic synthesis with static balancing was developed [10, 11, 12]. This study investigates a two-tension-spring-loaded four-bar hood linkage mechanism using the previously established one-step procedure approach. The primary objective of this study is to demonstrate the design of an optimal two-tension-spring-loaded four-bar linkage mechanism for static balancing in the presence of friction. Additionally, this research serves as a further application of the one-step mechanism design procedure. The results of this study include optimization outcomes that are compared with previously reported results.

2 Problem Statement and Results

This study introduces the kinematic synthesis and optimization of a four-bar automotive engine hood linkage mechanism equipped with two attached tension springs. The configuration of the mechanism is illustrated in Fig. 1, where tension spring 1 and tension spring 2 are connected to links [AC] and [ED], respectively. Link [AC] serves as the driver link, and it is important to note that the rotation directions of both links [AC] and [ED] are the same during the hood motion.

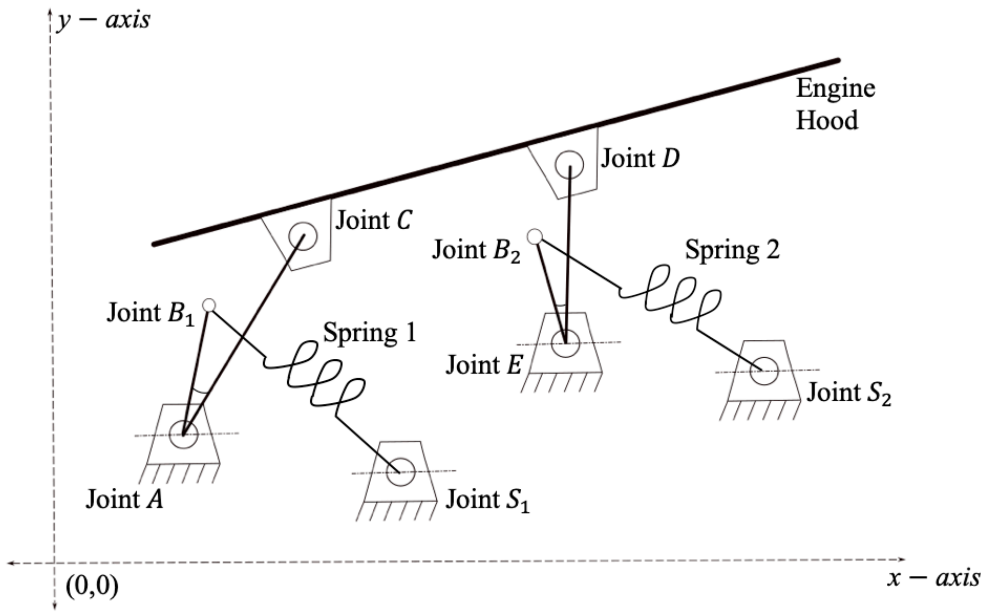

Figure 1: Two tension springs attached four-bar linkage mechanism

In this investigation, only the hood specifications are initially known: weight, length and the positions when fully-opened and fully-closed. The linkages and springs are assumed to be massless, with friction considered only at Joints *A, C, D* and *E.* To minimize the

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number of design variables, tension springs 1 and 2 are selected to be identical. The introduced four-bar mechanism comprises eleven design variables, which include the spring constant, the angles of B_1AC ($\angle(B_1AC)$) and B_2ED ($\angle(B_2ED)$), x and y coordinates of Joints S_1 and S_2, the zero-spring lengths of springs 1 and 2, and the lengths of link [AB_1] and link [EB_2]. Furthermore, the two-position kinematic synthesis provides six free choices [2], of which five are designated as design variables. Additionally, the friction torques at the joints are treated as a design variable, assumed to be uniform across the joints. Consequently, the optimization process involves a total of seventeen design variables, with the objective of minimizing the applied force – or the balancing force at peak points – required to open or close the engine hood. The optimization results obtained are compared with previously reported results for the same four-bar hood linkage mechanism.

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