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Cam mechanisms based on a double roller translating follower of negative radius

E. Sanmiguel-Rojas [a,*], M. Hidalgo-Martínez [b]

[a] Área de Mecánica de Fluidos, Universidad de Jaén, Campus de Las Lagunillas, 23071 Jaén, Spain
[b] Área de Ingeniería Mecánica, Universidad de Córdoba, Campus de Rabanales, 14071 Córdoba, Spain

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ABSTRACT

Constant-breadth cam mechanisms are characterized by the fact that the closure of the cam-follower contact is guaranteed thanks to the geometry and, therefore, auxiliary elements as springs are not necessary. On the other hand, cam mechanisms with a negative radius roller follower allow designing simple machines exerting remarkably high forces when the space is restricted. This work proposes a new constant-breadth cam mechanism with a double roller translating follower of negative radius. The cam profile is designed with an optimizing method based on Bézier curves.

1. Introduction

The goal of the constant-breadth cam mechanism is the elimination of the extra preloading constrains to prevent the loss of the contact between cam and followers. By the type of follower, constant-breadth cam mechanisms can be classified as of flat-faced follower or roller follower. Fig. 1(a) shows a cam mechanism with a parallel flat-faced double translating follower. In these mechanisms, the distance between the parallel flat faces of the follower is constant. They can operate either translating or oscillating follower if the appropriate desmodromic conditions are established [1]. Rothbart [2] shows for a constant-breadth cam with a flat-faced double translating follower that the displacement function of the follower can be defined freely in the interval between 0^o and 180^o, however, the remaining interval of the displacement function is imposed by the first one because the distance between the faces of the follower is constant. Koloc and Václavik [3] analyze a constant-breadth cam as a case of conjugated cam mechanisms. Zayas et al. [4] describe a generating process by means of circular arcs to design cams with both translating and oscillating followers. Using non-parametric Bézier curves, Cardona et al. [5] show a procedure which guarantees automatically the global continuity of the law of displacement for both parallel flat-faced double translating follower and parallel flat-faced double oscillating follower. Recently, these authors [6] have analyzed the influence of the inclination and offset of the translating follower in a constant-breadth cam mechanism. They also calculate the sliding velocities for both translating and oscillating followers.

Regarding constant-diameter cam mechanisms with a double roller follower of positive radius (see Fig. 1(b)), Rothbart [10] develops the equations of the radius of curvature in force-closed cam mechanisms which use both flat-faced and roller followers. Qian [7] studies a constant-diameter cam which operates a double roller follower. By the motion of the follower, the relations between the cam angle and the different geometric parameters are established. Lin et al. [8] and Shin et al. [9] develop design solutions for breadth cams with double roller followers with positive radius of curvature. This new method is based on calculating the coordinates

* Corresponding author.
E-mail address: esrojas@ujaen.es (E. Sanmiguel-Rojas).

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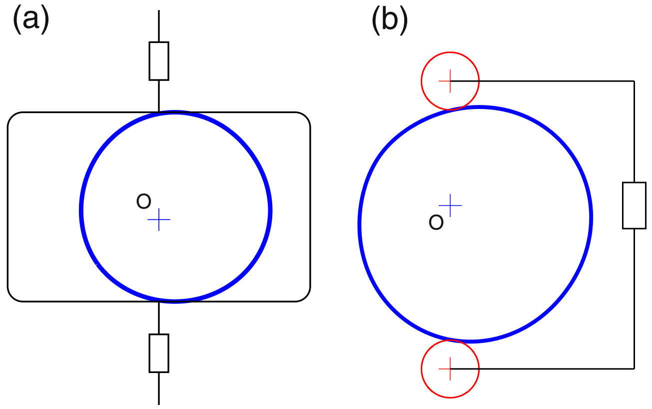

Fig. 1. (a) A constant-breadth cam mechanism with a parallel flat-faced double translating follower, and (b) a constant-diameter cam mechanism with a double roller follower of positive radius. The center of rotation of the cam (O) is also shown.

to determine the profile through each contact point. These authors use polynomial functions until seventh degree to ensure continuity in the cam profile.

On the other hand, the literature is sparse about cam mechanisms with negative radius roller followers. Carra et al. [11] develop a synthesis procedure, based on the modified trapezoidal curves, in order to generate the correct motion law for these cam mechanisms without undercutting problems. Recently, Hidalgo et al. [12] have proposed a numerical method for optimizing the design cams using a Bézier ordinate as an optimization parameter. As application example, they find the maximum of the follower lift, avoiding the undercutting problem, for the particular case of cam mechanisms with followers of negative radius.

There are many ways to express a cam profile mathematically. The procedures to generate the cam profile are deeply explained in the technical literature (see for example [10,13]). The functions to design the cam profile include splines, harmonic, cycloid, modified harmonic, trapezoidal, modified trapezoidal, polynomial, etc [10,14–18]. Other authors have shown that the Bézier curves are a powerful tool for designing cams [5,12,19–21]. However, these curves are much less widespread in this engineering field than the modified trapezoidal curves or the spline functions.

In the current work, a constant-breadth cam mechanism that operates a double roller follower of the negative radius is proposed as a new form-closed mechanism. As far as the authors know, this cam mechanism has not been analyzed before. The procedure to

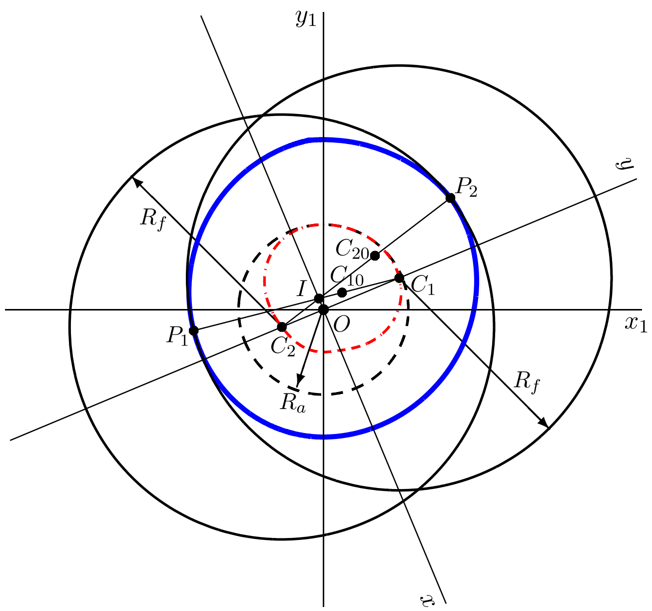

Fig. 2. Scheme and nomenclature used to generate the cam profile. The Oxy reference system is considered fixed to the frame while the Ox_1y_1 reference system is attached to the cam. Also shown the pitch curve (dash–dot red line), the prime circle (dashed black line) with radius R_a and both radii R_f of the follower. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)