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Study on the geometric characteristics of mating surfaces of globoidal cam mechanisms

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ABSTRACT

This work presents a complete and systematic method for the analysis and simulation of geometric characteristics of mating surfaces of globoidal cam mechanisms. Based on the fundamental forms of globoidal cam surface, the asymptotic curves, the principal directions and curvatures, and the Dupin's indicatrix are obtained and simulated. The curvatures of asymptotic curves are calculated to verify whether the cam surface is a ruled surface or not, which is an important issue to determine the machining process of the globoidal cam. In addition, the relationship between the local shapes of the cam surface and the motion periods is presented. The characteristic curves of relative normal curvature at different contact points are depicted and compared as well. Based on the Dupin's indicatrix, the indicatrix of conformity (Dr. Radzevich, 1980s) is first applied to analyze the contact geometry of mating surfaces of globoidal cam mechanism. The indicatrix of conformity in the case of contact of saddle-like surface with convex parabolic-like surface is first discussed here. A globoidal cam mechanism used in automatic tool changer of CNC machines is presented to clarify the outlined methods. The proposed methodology is important for design, manufacture, and contact analysis of globoidal cam mechanisms.

1. Introduction

A globoidal cam mechanism is a spatial cam mechanism, which is composed by a globoidal cam with ribs and a turret with rollers (Fig. 1). It is an intermittent motion mechanism to transmit a mechanical motion of a periodic variable speed between two perpendicular axes. Due to the high precision positioning, the globoidal cam mechanisms are widely used in the indexing mechanisms and the automatic tool changers of CNC machines. It is a complicated task to design and manufacture the globoidal cam. The simulation and analysis of geometric properties of mating surfaces for the globoidal cam mechanism, particularly at the design stage, plays an important role in predicting the contact area, the load distribution, the wear life, the friction, and so forth. In addition, it serves as basis to solve the problem of determining optimal parameters of the kinematic scheme of surface generation and of optimal parameters of the geometry of the generating surface of the form-cutting tool [1]. However, the studies on the comprehensive analysis and simulation of the contact geometry of the mating surfaces of the globoidal cam mechanism are sparse.

The comprehensive analysis of the globoidal cam surface is the basis for the study of the contact geometry of mating surfaces for globoidal cam mechanism. Professor Litvin [2–4] is a well known professor in the field of gear research covering the theory,

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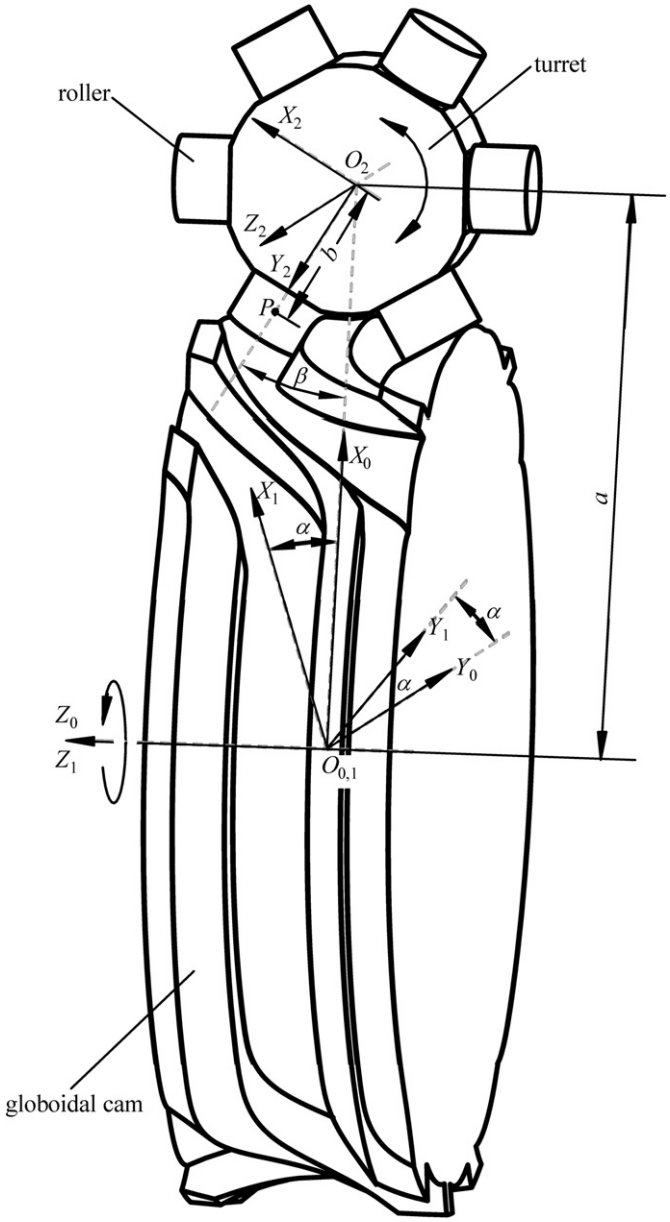

Fig. 1. The globoidal cam mechanism.

design, geometry, and manufacture of all types of gears and gear drives. It has been reported that the profile of a cam contour can be directly designed based on the transmission relationship between cam and follower, the basic size of the mechanism and the types of cam and follower [5]. A lot of works on the determination of principal curvatures and directions of globoidal cam surfaces are based on Litvin's theory, that is, they are derived on the premises of the principal directions of the roller type cutter and the relative motion parameters between cams and rollers at the contact point. However, the determination of principal curvatures and directions for the cam surface in this paper is much simpler, as it begins from the fundamental magnitudes of the globoidal cam surface.

Concerning the recent studies on the globoidal cam mechanism, many researchers have focused on the surface design and surface machining. The globoidal cam mechanisms with cylindrical rollers were extensively used. Backhouse and Jones [6] derived the geometric properties of a globoidal type cam, including values of pressure angles and cam surface curvatures. Yan and Chen [7] presented the mathematical expressions for the principal curvatures and directions, and the pressure angles of the globoidal cam with cylindrical rollers. Ji et al. [8] proposed a systematic approach for calculating the rib-thickness of globoidal cam based on the geodesics in differential geometry. Globoidal cams with meshing elements having other different geometries