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應用六軸 CNC 傘齒輪切齒機進行諧

波齒輪剛輪之強力刮齒加工

**Power Skiving for Producing
Circular Gear of Harmonic Driver on
Six-Axis CNC Machine**

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中文摘要

諧波齒輪減速機的優點在於擁有高減速比的特性，除了用於航空產業，現在也廣泛的運用在機械手臂中，諧波減速機主要由三個零件組成，分別為波產生器、柔輪和剛輪，其中剛輪為內齒輪，可以使用強力刮齒加工製造。近年來齒輪產業在圓柱齒輪開始採用強力刮齒的製造方法，其優點不但與滾齒加工相同，更可以用於生產內和外齒輪。刀具齒形設計為強力刮齒的關鍵技術之一，若能提出一針對不同齒輪的刀具齒形設計方法，將能使得強力刮齒可以更廣泛的被應用。另外強力刮齒刀具根據文獻可以發現多使用錐型設計，這種設計可以有效的避免刀具和齒輪間的干涉，缺點在於刀具重磨後齒形會有些微的誤差降低齒輪精度。若是使用圓柱型刀具的設計，便可以有效的改善重磨後的誤差問題，並且容易製造。

本研究將建立諧波齒輪剛輪之強力刮齒圓柱型刀具數學模式，及使用圓柱型強力刮齒刀具之六軸機切齒機械設定推導。首先建立諧波齒輪柔輪和剛輪齒形數學模式，接著推導零誤差圓柱型強力刮齒刀具輪廓數學模式，以及強力刮齒加工之機械設定。最後推導於六軸 CNC 傘齒輪切齒機的強力刮齒加工座標位置，進而編程加工 NC 碼，以進行諧波齒輪剛輪強力刮齒的模擬。

關鍵字：諧波齒輪、剛輪、強力刮齒、圓柱型刀具、零誤差刀具、六軸 CNC 傘齒輪切齒機

Abstract

The superiority of harmonic gear reducers is their high reduction ratio with compact design, that makes them be very common in aviation and mechanical industries. A harmonic reducer is mainly composed of three parts, which are a wave generator, a flex spline, and a circular spline. The circular flex spline is an internal gear which can be manufactured using power skiving (PS). PS is getting more and more popular in recent gear industry because it has the same advantages of hobbing process and can be applied to internal and external gears. Tooth profile design is one of key technologies for PS tool. If a design method of tool profile for different gears can be established, it will enable PS to be more widely used. In addition, according to the reference, PS tools are mostly designed as a tapered tool. This design can effectively avoid interference between the tool and the workpiece. The disadvantage of a tapered PS tool is slight errors inevitably found on its tool profile, and that reduces gear manufacturing precision after being resharpened. On contrary, if the PS tool is cylindrical type, the profile is identical in each resharpened face, and that enables tool to easy manufacture.

The paper aims to establish the mathematical model of cylindrical PS tool and to derive machine settings when the cylindrical tool is conducted. First of all, the mathematical models of the flex spline and circular spline are established, and then the mathematical model of the cylindrical tool profile with error-free and machine settings of universal machine are derived. Moreover, coordinates of the six-axis CNC bevel gear cutting machine can be derived according to inverse kinematics. Therefore, the PK can be implemented in this modern CNC machine with profile-error free.

Keywords: Harmonic gear reducer, circular spline, power skiving, cylindrical tool, error-free tool profile, six-axis CNC bevel gear cutting machine.