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厦门大学

硕　士　学　位　论　文

螺杆压缩机转子齿廓磨削关键技术
Key Technology of Screw Compressor Rotor's Tooth Profile's Grinding

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摘 要

螺杆压缩机以其平稳的高速性能、多相混输性、排气量稳定及易于操作维护等优点，广泛应用于各工业领域。螺杆压缩机核心部件螺杆转子的制造过程中，由于转子形状复杂，螺旋面成形困难、制造精度不易保证等技术难题，使得其成形原理及精密制造技术的研究一直是行业发展的重要研究课题。随着计算机科学和机械工程学科的发展与日益紧密的结合，现代制造技术得到飞速发展，出现了大量专用的螺杆转子数控装备及配套辅助软件，但其核心技术仍由国外所掌握。虽然我国在转子制造领域得到了很大进步，但与世界领先技术相比仍然存在较大的差距，主要表现为加工效率低、精度不高且精度保持性较差。

在此背景下，本论文围绕“螺杆压缩机转子齿廓磨削关键技术”这一课题，以实现精密、异形、复杂螺杆转子的高效、高精度磨削为目标，对以下几个方面做了较深入细致的研究：

1. 基于螺旋面成形原理建立了转子螺旋面与成形砂轮的接触条件数学模型。在转子实际型线数值分析的基础上，引入了累加弦长参数三次样条曲线求解转子端面型线上各型值点的一阶导数，解决了型值点的大挠度问题。

2. 求解了转子齿廓磨削用成形砂轮廓形数学模型，将数值分析方法应用于转子端面型线和成形砂轮轴向截形处理，通过二维和三维干涉检查方法评价与优化了成形砂轮廓形。

3. 分析了转子齿廓铣削、磨削工艺和磨削产生的齿廓误差，提出了一种针对齿廓误差的专用补偿方法。通过实际加工验证了该补偿方法的可靠性，并将该误差补偿方法应用于转子原始型线的调整，修正了转子原始测量误差和部分设计缺陷，优化了部分转子型线和压缩机综合性能。

4.开发了一套螺杆压缩机转子磨削计算软件，进行了转子虚拟仿真加工与现场试验， 验证了本文理论的正确性。

关键词：螺杆转子；成形砂轮；干涉检查；误差补偿；虚拟仿真

Abstract

Screw compressor has been widely applied in many industrial fields because of its great high speed performance, excellent multiphase transportability, stable exhaust performance and easy operability. As the core part of compressor, screw rotor's manufacture is complicated because the rotor's structural parameters are complex and diversified, its helical surface is hard to process and its manufacturing accuracy can't be guaranteed. Therefore the research for the technology of screw rotor that relates to the forming principle and sophisticated manufacturing has always been an important topic of the industrial development. With the development of the closer combination of Computer Science and Mechanical Engineering Science, and the great progress of the Modern Manufacturing Technology, a large number of specific CNC machines and relevant auxiliary software have emerged, but the core technologies are still possessed by foreigners. Although Chinese researchers have made a great progress in the manufacturing of screw rotor, there is still a big gap between our technology and the other sophisticated world-leading technology, which are mainly showed in the following aspects: manufacturing inefficiency, low accuracy and less stable quality.

Under this background, this thesis will study the key technology of screw compressor rotor's tooth profile's grinding, aiming at efficiently and accurately manufacturing the screw rotor of high-precision, abnormity and complexity. The main contents these papers discuss are as follows:

1. Upon the forming principle of the helical surface, the condition equation of contact line between helical surface and form grinding wheel has been established. On the basis of numerical analysis on the rotor's form line, accumulated chord length parameter cubic spline has been applied to calculate the first derivative of data points of screw rotor's sectional profile, and has solved the problem of some data points' large deflection in the rectangular coordinate system.

2. The mathematical model of form grinding wheel's edge has been derived. Numerical analysis has been applied to the rotor's sectional profile and forming

wheel's axis profile, and the forming wheel's profile has been evaluated and optimized through the 2D and 3D interference between rotor and grinding wheel.

3. After analyzing the milling and grinding process of screw rotor's tooth profile, some rotor's tooth profile errors after machining has been discussed and relevant solutions to improve the manufacturing accuracy has been proposed. A specific profile error compensation technology has been put forward which has been proved to be reliable and easily operated by the practice of actually manufacturing, then the technology has been extensively applied to the adjustment of original profile of screw rotor to modify the design flaws and origin measurement errors of screw rotor's tooth profile, and thus the overall performance of screw compressor has been improved.

4. This paper has developed a set of software to calculate the forming cutter's profile and generate the G-code for forming grinding wheel's dress. At last, we have simulated the rotor's manufacturing process with the help of CAD/CAM technology and done lots of field test of rotor's machining, and the result shows that the forming cutter's profile and the theory these papers proposed are right.

Keywords: Screw Rotor, Form Grinding, Interference Check, Error Compensation, Manufacturing Simulation

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