

叶片检验样板的数控加工工艺设计

顾京

(无锡职业技术学院科技与产业处, 江苏无锡 214121)

摘要: 汽轮机叶片制造中, 叶片叶型的内弧、背弧形状通常是使用样板来检验的。本文以 432 叶片内弧样板工艺设计为例, 通过分析叶片检验样板的技术要求, 介绍了采用数控磨削改进加工工艺的方法。

关键词: 检验样板; 数控磨削; 工艺设计; 程序

中图分类号: TH162 文献标识码: A 文章编号: 1009-9492 (2006) 10-0021-02

1 前言

叶片是汽轮机的核心部件之一, 它起着将蒸汽的动能转换为机械能的作用, 汽轮机效率的高低, 很大程度上取决于叶片型面的设计和制造水平。本例所讨论的汽轮机叶片属于自由曲面叶片, 叶片曲面部分由 7 个截面过渡形成, 每一截面由不同的数据形成型线, 各截面之间扭曲度较大。在叶型批量加工过程中, 通常采用简便的样板检验方法来控制叶片制造的形状精度。因而, 检验样板的精度尤其是样板型线的形状精度是保证检验质量的关键。

检验样板是根据叶片在不同截面上内弧和外弧的形状而分别设计的。432 叶片某一截面内弧样板图样如图 1 所示, 型线数据见表 1。叶片材料为 7mm 厚的 65Mn 钢板, 淬火硬度要求为 HRC55-60。传统工艺: 样板型线用线切割粗加工成形, 留钳修余量; 通过钳工修磨型线; 三坐标测量后再修磨来达到精度要求。主要存在问题: 由于采用手工钳修方法, 型线的轮廓度和尺寸精度难以可靠保证, 容易产生废品; 在修磨过程中, 需频繁地进行三坐标检测, 生产效率低, 生产周期长。

2 工艺设计

现利用在加工中心主轴上装夹的特制磨杆和平形砂

轮, 以数控磨削代替钳工修磨来加工型线, 以保证加工精度、提高生产效率。样板型线加工主要工艺内容: 数控电火花线切割型线; 钳修叶型处倒角 $4.5 \times 45^\circ$; 数控磨削型线, 轮廓度 0.03; 三坐标检验, 在型线宽度上每隔 5mm, 测量一点。

(1) 确定工艺方法

按试验数据, 采用线切割粗加工样板型线后, 所留磨削余量一般为单边法向 0.03mm。0.03mm 磨削余量将分两次进给完成, 其中, 0.02mm 是磨去线切割切痕, 0.01mm 作为精加工数控磨削余量。而且磨削一刀后, 就应该修正一次砂轮, 以保证加工精度。

(2) 选择砂轮及切削用量

砂轮品种: 参照国标 GB/T2484-1994, 采用 60 粒中硬白刚玉平行砂轮为宜。

砂轮直径、主轴转速: 砂轮直径过大, 易引起干涉; 直径过小, 得不到理想的线速度。此类砂轮工作速度在

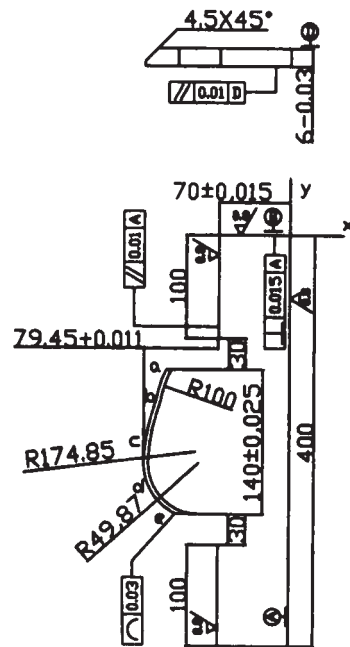


图 1 叶型内弧检验样板图样

表 1 叶型数据

节点	X	Y	线段及形状	R
a	-116.189	-130.000	ab 圆弧	100
b	-136.581	-161.615	bc 圆弧	174.85
c	-149.594	-217.248	cd 直线	
d	-149.594	-223.805	de 圆弧	49.87
e	-118.514	-270.000		

* 教育部示范性数控实训基地建设支撑项目之一 (苏教财 [2004] 96 号)

35m/s 左右。按 $V = \frac{\pi \cdot d \cdot n}{1000 \times 60}$ 公式计算，如选直径为 100 的砂轮，若主轴转速为 5000rpm 的，则可得 26.2m/s 的安全线速度。经多次试加工，砂轮直径范围选择在 100mm ~ 85mm 之间最为合适，不仅磨削性能好，且安全可靠。因磨削时样板型线处已经过倒角，其厚度为 1.5mm，所以选用 8mm 厚的平形砂轮。

进给速度：经试验，磨削的进给速度控制在 250 ~ 300mm/min，表面粗糙度能达到图样要求。

(3) 工艺过程

为充分发挥数控加工优势，有效控制加工精度，加工中利用刀具补偿功能来控制砂轮的修正量和磨削的深度。以样板型线的实际轮廓线来设计砂轮磨削路线，每磨削一刀，均应通过程序控制修正一次砂轮。进给过程中，再增加砂轮在 Z 轴方向的上下进给，以提高砂轮利用率、延长砂轮使用寿命。

3 程序编制

(1) 加工原点设置

修正砂轮加工原点：取砂轮修正器基准孔作为 X、Y 方向的加工原点，Z 轴加工原点取在当砂轮厚度约 1/2 处对准金剛笔尖的位置，如图 2 所示，把当前机床坐标系坐标值输入 G55，作为修正砂轮时的加工原点。

磨削型线加工原点：主轴夹寻边器 (或对刀棒)，以两

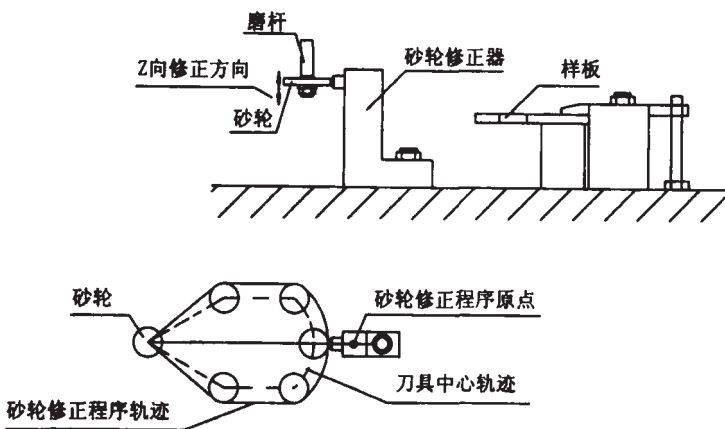


图 2 修正砂轮时的走刀路线

定位销位置确定加工程序原点的 X、Y 坐标值，Z 轴加工原点取在砂轮厚度约 1/2 处对准样板型线时的位置，如图 3 所示，把当前机床坐标系坐标值输入 G55，作为样板磨削时加工程序的原点。

(2) 粗磨程序

粗磨程序包括第一次修正砂轮程序和粗磨型线程序。

第一次修正砂轮时，在 G54 加工坐标系中，取 X=-200mm 处作为砂轮修正程序的起点和终点，走刀路线如图 2 所示。Z 向修正行程取大于砂轮厚度的 12mm。在

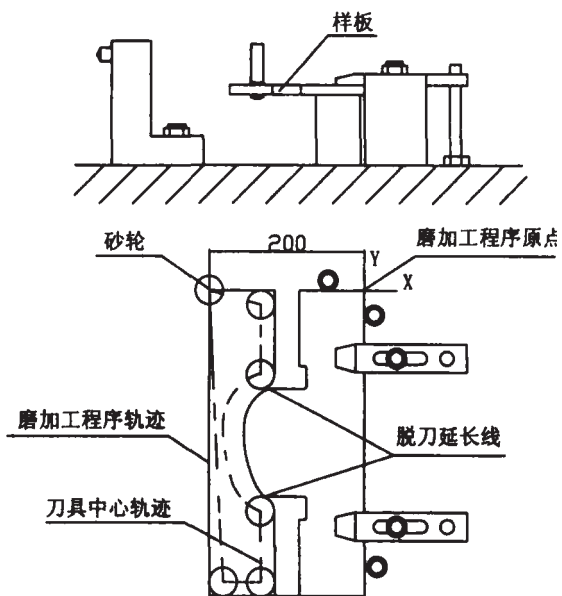


图 3 磨削样板时的走刀路线

刀具半径补偿偏置 H01 中输入砂轮半径值，修正一次砂轮。每次修正砂轮，约修去 0.1mm。砂轮修正程序略。

第一次粗磨样板型线时，取 G55 加工坐标系中 X 轴线上 -200mm 处，作为程序的起点。走刀路线主要由型线部分的三段圆弧 ab、bc、de 和直线 cd 组成，再加上切入切出的路线，走刀路线如图 3 所示。砂轮在 Z 轴方向的上下进给行程为 5mm。在刀具半径补偿偏置 H02 中输入的砂轮半径补偿值，比修正砂轮时的 H01 小 0.02，粗磨一次。磨削型线程序略。

(3) 精磨加工程序

第一次粗磨完成后，将砂轮修正程序中刀具半径补偿偏置 D01 中的值减去 0.1，修正一次砂轮，约修去 0.1mm。然后，在型线磨削程序的刀具半径补偿偏置 D02 中，输入比 D01 小 0.01 的值，即精磨量为 0.01mm，精磨一刀。

4 结论

根据生产图样编制三坐标测量仪测量程序，通过三坐标的精密测量和检验，样板型线的尺寸、轮廓度、粗糙度都达到图样要求。因而，样板型线的数控磨削加工工艺的应用保证了质量，提高了工效。

参考文献：

- [1] 宇富平. 数控编程在油管加工工艺上的应用 [J]. 机床与液压, 2006, (2): 229.
- [2] 党新安. 刀具半径补偿使用中出现过切及其解决办法 [J]. 组合机床与自动化加工技术, 2006, (2): 89.

作者简介：顾京，女，1958 年生，江苏无锡人，副教授，大学本科。研究领域：数控加工技术、高职教育。（编辑：吴智恒）

006-09-13 Characteristic Analysis of Ball Screw Feed System in High-Speed Machining

LI Ya-qin, LONG Ze-ming, HAN Yang-yang(Jiamusi University, Jiamusi154007, China)

Abstract: In this paper, the authors refer to problems about high-speed of ball screw feed system in high-speed machining, and introduce some important problems in details. At the same time improvement is proposed. Finally the authors prospect the development direction of feed system in high-speed machining.

Key words: high-speed machining; feed system; ball screw

006-09-15 The Research of Surface Roughness on High-Speed Planar Milling Based on ELMAN Network

LI Zhong-ke, ZHANG Yu, ZOU Hao-bo, ZHANG Chun-fei (CIMS Application & Research Center, Faculty of Mechanical and Electrical Engineering, Kunming University of Science and Technology, Kunming650093, China)

Abstract: This paper establishes the model with the artificial nerve-network on condition of high-speed planar milling, to research the influence of cutting parameter to surface roughness. The network is trained by series of datum, which are obtained through high-speed cutting experiment with the orthogonal experiment method. And based on the network, the influence of cutting speed, cutting depth and feed per tooth to the surface roughness are discussed and forecasted. The performance of the model is tested with experiment datum, and the good result is obtained. It shows that the model can be used to forecast the surface roughness on high-speed planar milling.

Key words: ELMAN nerve-network; high-speed planar milling; surface roughness; combinatorial data with the orthogonal experiment

006-09-17 Research on the Method of Calculation of Process Dimension Chains

ZHANG Pu-li(Shanxi Polytechnic Institute, Xianyang712000, China)

Abstract: It is of great importance to determine the dimensions of working operation in making mechanical processing procedure. When process reference is coincident with the design reference, anti-derivation principle is used to determine process dimension according to the process allowance and economy precision. While process reference is not coincident with the design reference, it is needed to use the principle of dimension chain to calculate the dimensions of working operations. In this paper, combined with the machining of gear hole, a new method of analyzing and calculating the process dimension chains is discussed in details.

Key words: research; process dimension chains; calculation method

006-09-21 The Design for the Test Model of Blade in NC Technology

GU Jing(Wuxi Institute of Technology, Department of Technology and Industry, Wuxi214121, China)

Abstract: Inner arc and carry arc of the blade have been tested by the model in processing steam turbine blade. Taking the model technological design of the inner arc of the 432 blade as an example, this paper introduces an improving method of NC grinding, through analyzing the technological requirement of the blade test model.

Key words: test model; NC grinding; technological design; program

006-09-23 A Series of Special Clamps Design of Body of Shoot Liquid Pump

HE Bing-qiang¹, YU Hai-xu²(1.Guangdong Technical College of Water Resources and Electric Engineering, Guangzhou510635, China; 2.Guangdong Radio and TV University, Engine lecturer, Guangzhou510091, China)

Abstract: This article introduces a series of special clamps for machining pump body of a Shoot Liquid Pump. These special clamps are proved by practice, which can make shell parts with more and more side holes with high quality, and screw thread accord with England and USA system. They have good working effect, easy technology effect, saving time and labor and so on.

Key words: pump body; working; special clamps

006-09-28 The Methods of Tool Setting and Errors of Analysis CNC Lathe

ZHU Shu-hong (Zhangjiajie College of Aerospace Industries Professional Technology, Zhangjiajie427000, China)

Abstract: Cut-and-try procedure of tool setting is widely used in CNC lathe. This paper introduces two kinds of methods of tool setting, which are absolute coordinate and opposite coordinate, and analyzed their principle and errors.

Key words: CNC lathe; cut-and-try procedure; method of tool setting; principle and errors

006-09-29 Study on Parameters Self-tuning Fuzzy PID Control of Piezoelectric Actuator

DENG Jun-guang¹, ZHANG Xian-min², WANG Hua² (1. Department of Mechanical Engineering, Shantou University, Shantou515063, China; 2.College of Mechanical Engineering, South China University of Technology, Guangzhou510640, China)

Abstract: In this paper, a parameters self-tuning fuzzy PID control technique is developed to overcome the effect of the hysteresis and nonlinearity on piezoelectric actuators. It automatically tunes the proportional, integral and derivative gains