螺旋焊管在线自动测径装置

刘 洪 飞
(辽阳钢管厂　111000)

摘　要　螺旋焊管在线测径是生产高标准焊管的重要检测装置,可以实时监控钢管管径。选用CCD传感器与计算机连接,组成钢管测径装置,能够较好地达到对钢管管径实时监控的目的。

主题词　螺旋焊管　传感器　监控　测径

1　概　述

螺旋焊管在生产过程中,对管径的控制是十分重要的,只有对生产出的管坯直径和椭圆度进行实时测量和控制,才能保证生产出合格的钢管。制管厂家大部分采用钢卷尺缠绕在管坯外壁上测量钢管周长的方法来检查钢管直径的大小。对于连续生产∅820 mm以上管径的螺旋焊管来说,采用钢卷尺人工测量既不方便,又会产生较大的误差。因为人工用钢卷尺测量管径,受操作者素质和测量工具精度的影响,由于管坯焊道过热,使钢卷尺在管壁上受热拉长,产生测量误差,因此存在着测量不准确和不及时等缺点,制约着钢管生产的质量。然而,管道设计者和用户为了保证钢管在工地对接时环形焊缝不产生错边,减小应力集中,对钢管管径的精度要求十分严格,尤其是在那些高质量的重点工程管线上,要求往往超出了GB9711.1-1997标准和API Spec 5L标准。例如,"西气东输"∅1 016 mm×14.6 mm钢管,要求管体外径允许偏差为+0.3%D～-0.35%D,管端外径允许偏差为+2.0mm～-0.5mm,这些都比GB9711.1-1997标准和美国API Spec 5L标准严格得多。要达到这一标准就要在钢管成型工序及时地测量出管径大小,并及时调整管径。因此,用钢卷尺人工测量管径这种方法已经不适应在线生产测量钢管管径。要满足测量控制管径的目的,使之不出现管径超标准,降低废品率,需要对钢管管径进行实时监测,测量的方法要具有及时性、准确性、可靠性。因此在成型工序实施在线管径监测,采用微电子技术测量不仅能够克服人工操作和工具带来的测量不准确弊病,而且能够及时把当前生产的钢管管径测量、显示出来,以使成型操作者及时进行调整。笔者认为用钢卷尺人工测量管径作为辅助测量是必要的,但在连续生产钢管的成型工序上利用微电子技术实现自动化测径更为必要。

2　钢管直径测量方式

2.1　测量方式

钢管直径测量方式大体分为两种,一种是接触式测量,另一种是非接触式测量。接触式测量采用测量元件直接接触管体测量,如用位移传感器直接接触管坯测量;非接触测量采用传感元件,如用涡流传感器、光电传感器与管体保持一定的距离进行测量。如图1所示,采用接触式测量钢管直径,在成型机出管方向安装测量装置,钢管成型即使很稳定,管坯外圆也会有微小的摆动。这种方式容易造成误差,测量的结果是管坯的外圆的弦长,其平均长度$L_{平均}$为:

$$L_{平均}=\frac{L_1+L_2+L_3+\cdots+L_i}{i}$$

式中　$L_{平均}$—管体外圆平均弦长;

$L_1\cdots L_i$—采集i次管体外圆弦长$L_{平均}\leq D$。

因此,这种测量方式误差较大,在实际生产中一般不采用这种测量方式。

如图2所示,采用无接触式测量钢管直径,钢管外径部分遮挡发、收信号,在某一时间内传感器采集的数据计算出平均直径:

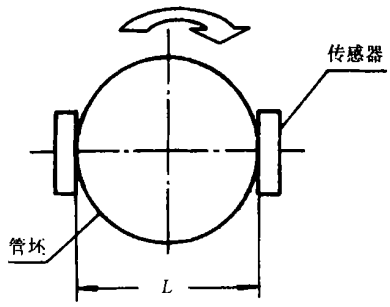

图 1　接触式测量钢管直径

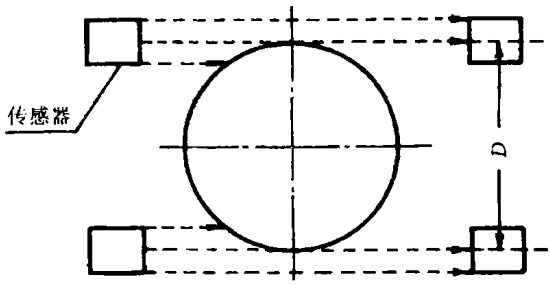

图 2　无接触式测量钢管直径

$$D_{平均}=\frac{D_1+D_2+D_3+\cdots+D_i}{i}$$

这种方法能够比较准确地测出钢管直径。

还有另一种模拟式测量, 测出相关量进行运算, 得出钢管直径。钢管成型角计算公式:

$$\cos\alpha=\frac{b}{\pi(D_w-t)} \tag{1}$$

式中　α—钢管成型角, (°);

b—成型用钢板宽度, mm;

D_w—钢管外径, mm;

t—钢板厚度, mm。

进入成型器板速 v_j 与从成型器出管速度 v_c 的关系是:

$$\cos\alpha=\frac{v_c}{v_j} \tag{2}$$

式中　v_c—管坯从成型器中出管速度, m/min;

v_j—带钢进入成型器的速度, m/min。

由(1)、(2)式得: $D_w=\frac{v_j}{v_c}\cdot\frac{b}{\pi}+t$ (3)

从(3)式中可以看出, b、t 是常量, v_c、v_j 用现代电子技术可以测出, 用计算机处理技术可以得出钢管的周长 πD_w, 通过某一时间内采集数据进行比较取最大值 D_{max} 和最小值 D_{min}, 就可以得出钢管的椭圆度:

$$\varnothing=\frac{D_{max}-D_{min}}{D}$$

式中　D—钢管公称外径。

这种方法不是直接测量钢管的管径, 得出的钢管直径也有误差。

早在 20 世纪 70 年代, 日本铁新社制管厂采用位移传感器测量管径如图 3 所示。原理是用一根直径为 3～5 mm 的多股柔性钢丝绳缠绕在钢管外壁上, 一端固定, 另一端用一个微型电机小车带动位移传感器测量管径, 钢丝绳的长短就是钢管管径的大小, 这种方式类似于我们用钢卷尺测量管径, 其优点是可以在管坯上任何一处测量管径, 但不能测量出钢管的椭圆度。

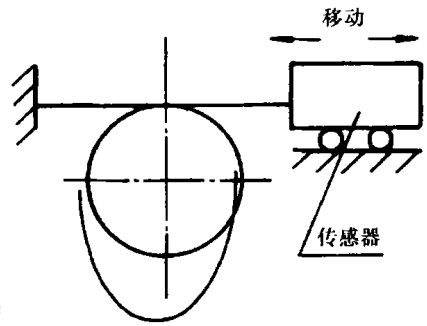

图 3　位移传感器测量管径

2.2　CCD 测径原理

随着电子技术的迅速发展, 传感元件不断更新, 采用电荷耦合器- CCD 器件, 可以比较容易地解决测量钢管直径这一问题。CCD 器件集成度高, 光敏元件间距小, 几何尺寸严格, 每个光敏元件位置可以寻址, 可以用工控机或单片机实现智能化控制, 由于 CCD 构成图像传感器具有体积小、功耗低、寿命长等优点, 作为像感元件精度高, 可以无接触检测, 螺旋焊管应用 CCD 作为传感元件测量管径最为合适。

(1) 螺旋焊管应用 CCD 测径原理见图 4

选用普通无闪烁灯光源, 用毛玻璃罩在外面, 放在钢管的一侧作钢管的背影光, 另一侧在钢管的下边缘与背影光相对应放一个 CCD 线阵传感器, 作为测量钢管底边上下变化传感元件; 在钢管的上边缘放置一个 CCD 线阵传感器, 作为测量钢管顶边缘上下变化传感元件, 传感器选用 TCD 141C, 5 000 像素, 点距 7 μm, 因此钢管上下边缘可各测 0～35 mm 的变化量。在 CCD 传感器前面, 由于一部分光线被钢管遮挡, 另一部分光线照射在 CCD 传感器上, 产生输出波形, 测得的直径则是: L_0+ 上边缘被光遮挡的光电像素的长度 ab+ 下边缘光电像素被遮挡的长度 cd, L_0 是上边

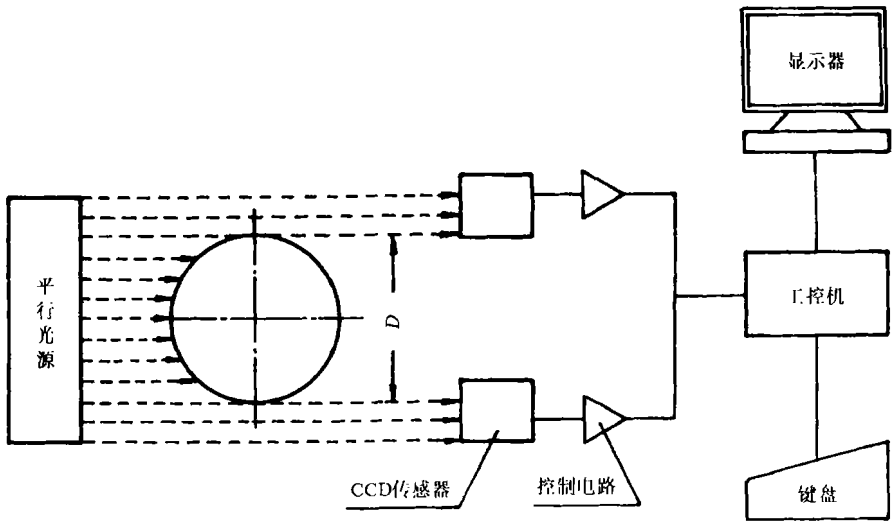

图 4　CCD 测径原理图

缘 CCD 传感器到下边缘 CCD 传感器的距离, 距离的大小根据管径大小确定, 由步进电机升降系统调整, 见图 5。传感器和光源安装在钢管随动装置上, 随动装置随着旋转的管坯前进, 就可以测量出钢管的某一截面的直径和椭圆度。经过传感器在某一时间内采集的数据, 计算机及控制电路通过数据处理就可得出钢管的平均直径 $D_{平均}$。

$$D_{平均}=\frac{\sum D_i}{i}$$

式中　D_i—传感器在某一时间采集第 i 个钢管直径数据, 即: $D_i=L_0+ab+cd$;

i—采样次数;

$D_{平均}$—钢管算数平均直径。

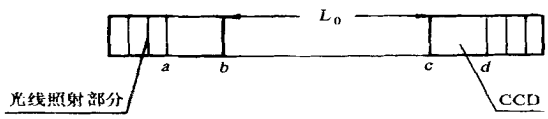

图 5　CCD 测径

在钢管同一截面上取最小直径 D_{min} 和最大直径 D_{max}, 计算出钢管某处的椭圆度 $\varnothing$:

$$\varnothing=\frac{D_{max}-D_{min}}{D}$$

式中　D_{max}—在同一钢管截面内钢管最大直径;

D_{min}—在同一钢管截面内钢管最小直径。

(2)CCD 测量钢管直径技术参数及功能

根据螺旋焊成型机组生产能力选技术参数:

a) 测量管径范围: ∅377 mm～∅1 020 mm;

b) 测量管径: 用周长法测量精度±0.02mm;

c) 管坯上下跳动量: ±10mm, 可以准确地测量出周长;

d) 实时打印报表;

e) 实时屏幕显示。

2000 年我们和有关单位成功研制出 CCD 传感器测径装置, 并投入使用, 在生产西气东输钢管上使用良好。该装置能够准确地测量出管径和椭圆度, 并能对钢管直径进行及时控制, 生产出的螺旋焊管满足了西气东输的技术标准。

3　结　语

螺旋焊管在线测径是生产高标准螺旋焊管的重要检测装置, 利用它可以达到对钢管管径实时监控的目的, 从而保证生产出满足质量要求的合格钢管。

参 考 文 献

1　鲍敏杭等. 集成传感器. 北京: 国防工业出版社, 1987

作者　刘洪飞, 1982 年毕业于抚顺石油学院机械系, 毕业后从事焊管机械设计工作。1996 年晋升高级工程师, 担任辽阳钢管厂技术研究所副所长、所长, 现任辽阳钢管厂生产设备科科长。通讯地址: 辽阳市文圣区鹅房街 7 号　东北输油管理局辽阳钢管厂生产设备科　电话: (0419)4322967 转 58554

(收稿日期: 2002—05—10)

Abstract: The main process parameters (welding temperature, welding pressure, welding speed and strip thickness) of welding process are optimized to ensure the stability of welding temperature and welding pressure, and this is the reliable method to improve H. F. welded pipe welding quality. Based on new technology of current international welding process automatic control, a set of advanced H. F. welded pipe welding process computer automatic control system was proposed. Through long term study, the proposal is considered to be mature and more advanced under support of advanced hardware and software system. This control system can optimize welding specification, improve weld seam quality.

Subject Terms: high frequency welded pipe welding process weld seam quality computer automatic control

Introduction to Roller Pass Design Software

Li Yong, Li Guorong, Liu Liyong (22)

Abstract: A kind of roller pass design software was introduced. This kind of software can process many kind roller pass design such as round pipe, irregular pipe, cold bending steel and obtain favorable economic benefit. The advantages are short design period, high efficiency and low failure rate.

Subject Terms: roller pass design software

Research on Spiral Welded Pipe Online Automatic Diameter Measure Equipment

Liu Hongfei (24)

Abstract: Spiral welded pipe online diameter measurement is an important equipment to produce high quality welded pipes. This equipment can monitor steel pipe diameter real time, the selected CCD sensor connected with computer to form into pipe diameter measure equipment, and meet the requirement for real time pipe diameter monitoring.

Subject Terms: spiral welded pipe sensor monitor diameter measure

Attracting Foreign Capital and Assets Intergration Are Effective Methods of Inspiring Existing Assets of State Owned Enterprises

Zhong Yuming (27)

Abstract: The author is responsible for the joint venture project between Baoji Petroleum Steel Pipe and Tube Works and Sumitomo Metal Industries, Ltd, for four years. Based on the practice of China state owned enterprises and the sample of foreign capital introduced into Baoji Petroleum Steel Pipe and Tube Works and its assets reset, form theoretic and joint venture working practice, the Gateway are through assets reset, introducing into foreign capital, reforming of inner enterprise economic structure, product structure and management level to increase the enterprise competition and improve the economic benefit under the current condition of few state new increment input.

Subject Terms: state owned enterprises assets reset introduce into foreign capital activate existing assets gateway

Selection and Execution of High Precision ∅340 mm HFW Pipe Orientation and Quality Specification

Zhang Yanjiang (33)

Abstract: In order to improve our product quality to the international advanced standards, avoid repeating construction of low quality standards, occupy the steel pipe market of high added value and meet the international customer's requirements of high precise and high quality welded pipes, the problems concerning about product market location and product quality standards selection and application were analyzed by Tianjin Shenzhoutong Steel Pipe Co. Ltd. during establishment of welded pipe mill of high precise D340 mm HFW welded pipes.

Subject Terms: welded pipe mill HFW longitudinal welded pipe product Standard Internal control standard

Manufacture Procedure Layout and Equipment Selection of High Precise D340mm HFW Welded Pipe

Liu Dongming (37)

Abstract: The establishment of high precise HFW steel pipe mill was proposed. Based on pipe-making experiences over 20 years and international HFW welded pipe trends, the science decision was made through analyzing product scope, procedure layout and equipment selection, and the fixed foundation for smoothly construction and production of high precise D340mm HFW welded pipe mill was reached. Meanwhile the wholly home-made same type of mill in China was realized and product quality was improved to or above international advanced standards.

Subject Terms: longitudinal welded pipe standard machine group equipment manufacture procedure

Researching and Manufacturing of Automatic Control Super Spiral Accumulation Storage

Wang Liyong (41)

Abstract: The Components and working theory of horizontal spiral accumulation storage in the D325mm longitudinal welded pipe mill and relevant designation and rules concerning about spiral accumulation storage were introduced.

Subject Terms: spiral accumulation storage work theory feeding material designation rules

F. F. Forming Methods Application in D340 mm HFW Longitudinal Welded Pipe Mill

Li Jinping, Li Linxing, Sun Yaowen (43)

Abstract: F. F. forming method is the multi-function roller method, a new forming method in longitudinal welded pipe manufacturing process with advantages of stable forming, good common use of roller, less roller consumption and convenient production arrangement. Combined with the international advanced technology and experiences, D340mm longitudinal welded pipe mill developed by Taiyuan Huaye Equipment Research Institute, and applied into the production line of Tianjin Shenzhoutong Steel Pipe Co., Ltd. is one of the most advanced and the best e-