螺旋焊管挤压装置改进及摩擦分析

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摘要　在高频对接螺旋焊管试验生产中，将恒位置立辊挤压装置改为恒压力平辊装置，对两种装置的摩擦参数进行了分析比较。通过公式计算结果和生产试验表明：立辊装置的摩擦力是平辊装置的1.3倍，平辊装置更有利于待焊带钢两边缘的靠拢，从而能获得更稳定的对接焊缝。

主题词　螺旋焊管机组　高频焊　挤压辊　成型压力

1　引言

目前，在高频螺旋焊管的生产中，国内外普遍采用搭接焊工艺，这种工艺对带钢的要求、成型的精确性要求不太高，比较容易实现，但其有着难以克服的弱点：刨边量不易控制、内外毛刺无法处理、质量检测不能保证、容易出现根部裂纹等等[1][2]。国内的几套这种方式生产线生产的焊管一直存在质量问题。因此，研制和开发高频螺旋焊管的对接焊生产技术对现有机组的改造，对螺旋焊管技术的发展，都有着积极的意义。要实现对接焊，除了要有特殊的成型装置外，挤压装置也极为重要。因为挤压装置不仅仅是施加焊接压力，它对管坯的稳定合缝、恰当合缝角的形成及递送力大小的确定、成品管外径尺寸等都有很大影响。文献[3]中提出了用丝杆滑块调节的恒位置立辊装置，立辊孔型与管坯包络，管坯在立辊间作螺旋运动（图1）。这种装置调整后，立辊位置便恒定，形成的孔型就确定了，故能保证较准确的外径，但当带钢尺寸有偏差或成型不准确时，将导致挤压力变化，从而引起漏焊或挤压过量，使得焊缝质量不稳定；同时，该装置中管坯所受摩擦力大，且其对递送、合缝及出管不利。为此，本文将其改为恒压力平辊装置（图2）。

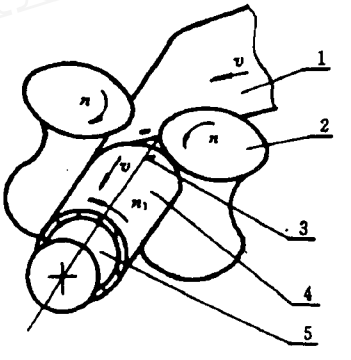

图1　挤压辊为立辊

1—板带　2—立辊　3—高频电极

4—焊管　5—芯棒

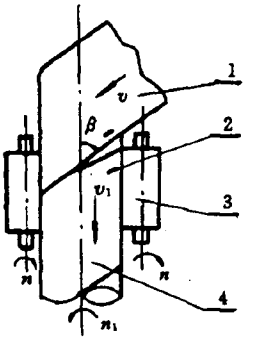

图2　挤压辊改为平辊

1—板带　2—高频电极

3—平辊　4—焊管

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2　立辊装置摩擦参数分析

立辊装置中,管坯与立辊间摩擦状态比较复杂,为便于分析,将管坯运动分解为周向旋转运动及轴向前进运动。旋转运动中,管坯与立辊间为纯滑动摩擦;前进运动中,二者间为滚动摩擦与滑动摩擦结合的滚滑摩擦。文献[3]中对这种两种摩擦进行了研究,指出了管坯在挤压辊间所受的主要阻力是由管坯旋转运动引起的。为了与平辊装置比较,将其结果列出:

旋转运动中管坯受到的阻力矩为:

$$M = \mu_h \pi R_1 W \tag{1}$$

式中:μ_h—滑动摩擦系数;

R_1—焊管半径;

W—挤压力。

由 M 抵耗的板带递送力为:

$$F_{z1} = \mu_h \pi W / \sin\beta \tag{2}$$

式中:β—成型角。

轴向前进运动摩擦力抵耗的递送力为:

$$F_{z2} = \frac{\pi \mu_h W k_1}{\cos\beta} \tag{3}$$

其中,$k_1 = (1 + \frac{\mu_c}{\mu_h}) - \frac{\pi R_0 - 2R_1}{\pi \cdot (R_0 - R\cos\theta_0)}$

式中:μ_c—滚动摩擦系数;

R_0—立辊最大半径;

θ_0—立辊滚动半径处角度。

由(2)和(3),得到总的抵耗递送力:

$$F_1 = F_{z1} + F_{z2}$$

$$= \mu_h W (\frac{\pi}{\sin\beta} + \frac{\pi k_1}{\cos\beta} \tag{4}$$

3　平辊装置摩擦分析

平辊为圆柱形,其轴线与管坯轴线平行,管坯相对于平辊仍作螺旋运动,其旋转运动中,管坯与平辊间为纯滚动摩擦,前进运动中二者间为纯滑动摩擦。压力的恒定是通过液压系统来实现的。

3.1　管坯周向摩擦力(滚动阻力)

两圆柱体相接触,滚动阻力为[4]:

$$F_c = fW \tag{5}$$

式中:f—滚动阻力系数,

$$f = k_2 \frac{2\pi}{3} \cdot \frac{a}{R'} \tag{6}$$

k_2—弹性滞后损耗系数,

$R_2 = 3.3 \times 8\% = 0.264$;

a—接触宽度(图 3),

$$a = \sqrt{\frac{4WR'(1-\gamma_1^2)}{l\pi E'}};$$

R'—等效半径,

$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2};$$

l—接触长度;

E'—等效弹性模量;

$$\frac{1}{E'} = \frac{1-\gamma_1^2}{E_1} + \frac{1-\gamma_2^2}{E_2};$$

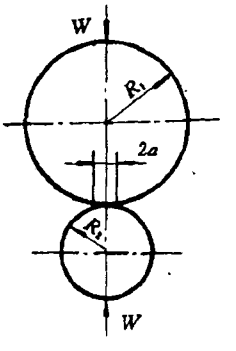

图 3

这里,$\gamma_1 = \gamma_2 = \gamma$,$E_1 = E_2 = E$,

则:$\frac{1}{E'} = \frac{2(1-\gamma_1^2)}{E}$,

R_2—平辊半径,

γ—泊松比。

将以上各式代入(6)式,得:

$$f = 0.453 \frac{R_1 + R_2}{\pi(R_1 - R_2)} \cdot \sqrt{\frac{W}{l\pi E} \cdot \frac{R_1 R_2}{R_1 + R_2}} \tag{7}$$

将(7)式代入(5)即得 F_c,于是,由滚动阻力抵耗的递送力为:

$$F_{z1} = 2 \cdot \frac{F_c}{\sin\beta} = 2 \cdot \frac{fW}{\sin\beta} \tag{8}$$

3.2 管坯轴向摩擦力(滑动阻力)

由于是纯滑动摩擦,由库伦定律:

$$\tau = \mu_h p$$

式中:

p—分布压力,沿接触宽度设为半圆分布,

$$p = \frac{2W}{\pi a l}\sqrt{(1-\frac{x^2}{a^2})}$$

每个平辊对管坯摩擦力为:

$$T = 2\int_0^a \mathrm{d}\tau = 2\int_0^a \mu_h \cdot \frac{2W}{\pi a l}\sqrt{1-\frac{x^2}{a^2}}\mathrm{d}x$$

$$= \mu_h \cdot W$$

两个平辊总的摩擦力为:

$$2T = 2\mu_h \cdot W \qquad (9)$$

由此抵耗的递送力为:

$$F_{x2} = \frac{2T}{\cos\beta} = 2\frac{\mu_h W}{\cos\beta} \qquad (10)$$

由(8)及(10)式得平辊装置总共抵耗的递送力为:

$$F_1 = F_{x1} + F_{x2} = \frac{2fW}{\sin\beta} + \frac{2\mu_h W}{\cos\beta} \qquad (11)$$

4 两种装置比较

由(4)及(11)式,两装置抵耗的递送力之比为:

$$S = \frac{F_1}{F_2} = \frac{\mu_h(\frac{\pi}{\sin\beta} + \frac{\pi k_1}{\cos\beta})}{\frac{2f}{\sin\beta} + \frac{2\mu_h}{\cos\beta}} \qquad (12)$$

在实际应用中,f 常忽略不计,$1+\frac{\mu_c}{\mu_h}\approx 1$,

则:$S = (\pi k_1 + \pi\mathrm{ctg}\beta)/2 \qquad (13)$

β 通常在 40°～70°,θ_0 一般在 60°～75°之间,当 $R_0=100$,$R_1=50$,$\beta=53°$,取 $\theta_0=70°$ 时,$S=1.3$。可见,克服立辊装置摩擦所需递送力是平辊装置的 1.3 倍左右,新装置减少了摩擦力,降低了能耗,有利于顺利出管。在∅100mm 试验轧机上试验,新装置消除了立辊装置生产中常发生的管坯被卡死等现象。

更为重要的是,立辊装置中的主要摩擦力—周向摩擦力作用的结果是使彼此靠近的待焊两边缘分开,如图 4 中 τ_1 的作用;而平辊装置中周向摩擦力是滚动阻力,很小,其影响可不计,而其轴向摩擦力作用的结果是使两边缘有靠近的趋势,如图 4 中 τ_2 的作用,从而有利于合缝。至于两种装置挤压辊摩擦力的作用对管坯引起的位移、应力、应变分布,可用有限元法进行数值计算。

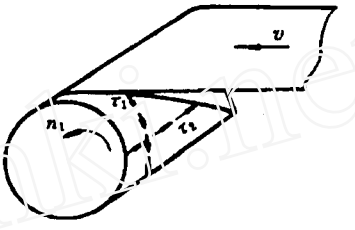

图 4

当然,由于新装置采用的是恒压力调整,挤压量将是变化的,当带钢宽度变化,有月牙弯或成型位置不准确时,挤压辊施加的压力不变而其移动量将有所改变,这些变化最终引起直径的波动,但经分析计算,该波动完全可以很容易地控制在 API 标准规定的直径公差内。

综上所述,理论分析和试验均表明:恒压力——平辊挤压装置能有效地减小挤压辊对管坯的有害摩擦力及其对管坯的损失,同时能获得优良稳定的对接焊缝,为螺旋焊管高频对接技术的实现提供了可行的途径。

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ABSTRACTS
WELDED PIPE AND TUBE
Vol. 17 №5 Sept. 1994

Yu Enlin, Lai Mingdao, Cai Songqing(1)

Elastic—plastic Finite Element Large Displacement Analysis of Thin Plates

Elastic—platic large displacement bending of thin plates involves material and geometrically nonlinear analysis. In this, the finite element models are obtained by means of translations of coordinate systems and small displacement formulas of thin plates. Analysis of straight seam tube forming process are carried out. The vesulst demonstrate that this method is effictive to analyze elastic—plastic, large displacement bending of thin plates.

Subject terms: mechanics of materials mechanical model stress state

Huang Shuju, Deng Zengjie, Jin Shilin(5)

CO_2 Corrosion of X70 Transportation Pipes and J55 Casing Tubes

The corrosion behaviors of the parent metal and the weld of two types of X70 and J55 specimens in CO_2—containing salt solution have been studied. The result shows that CO_2 makes the rate of corrosion, the tendency of pit and crevice corrosion increase, while the increased margin is influenced by the metallurgical parameters, including chemical composition, microstructure and so on.

Subject terms: transportation pipe casing tube CO_2 corrosion

Ding Qingru(10)

The Experiment on Materials Selection of Argom—Arc Welding Wire for F—Grade Pipe of Alkanisation Refining Equipment

A study on mechanical behaviour, weldability, corrosion properties and microstructure of welding wire H08Mn2Si and H10MnSi at home is made. The substitution posibility of welding wire at home for wilding wire TGS—50 from Japan is discussed.

Subject terms: argon—shielded arc welding pipeline machanical property corrosion resistace weldabilety

Lu Guofeng(14)

The Development of High Lampcolumn made of Longitudinally Welded Taper Pipe

Taper pipe lampcolumn with 6—20m height are developed in Hongli lamp and lampstand factory. The lighting area of the high—column lamp is $10^4 m^2$, and straightnees deviation of lampcolumn is not larger than 1/1000 of lampcolumn height. The manufacture process of the lampcolumn are: cutting of plate; forming of taper pipe; submerged arc welding; straghtening; polishing; galvanizing and inspecting etc..

Subject terms: special shape welded steel tube exciter lamp luminaire marking machinary

Chen Shaojie, Cheng Yongxiao, Wang Jizhong(16)

The Improvement of Extruding Installation and Friction Analysis in Spiral Welded Pipe

In the production of H. F. butt spiral welded pipe, the vertical roll extruding installation with fixed position are changed into horizontal roll installation with fixed pressure. The friction parameters of both installation are analysed. The results of calculation and experiment show that friction force of vertical installution is 1.3 times as large as that of horizontal one. A stable butt welt could be obtained in horizontal roll installution

as both edge of steel belt colse easily.

Subject terms: spiral weld—pipe mill high frequency welding extrusion—forming roll forming pressure

Fu Zhengrong, Lu Zhijian, Yu Xuewen etc. (19)

Design of ∅219 Longitudinally Welded Pipe Mill

∅219 longitudinally welding pipe mill has been designed on the basis of analysis to properties and parameters of same kind of the mill abroad and at home. The principal contents of the paper are as follows: basic parameters of the mill; technological process; the determination of shaping zone length; design of transmission system of shaper; the diameter determination of vertical and horizontal rolls; the pass selection of directive roll, exrtuctive roll and shaping roll; the structure chracteristics of inner—wall burr toll, looper, coil—opener and straghtener, shearing—welder and fly—saw. Finally, some design shortages are also poinved out.

Subject terms: pipe welding machine HF welding technological desing technological parameter

Wang Yuhua(25)

The Improvement of Argon—Arc Welding Gun with 3 cathodes

The operation principle and structure chracteristics of a key equipment—argon—arc welding gun with 3 cathodes in stainless steel welded pipe mill imported from abroad are analysed. Portial structures of argon arc welding gun have been improved. For example, the diameter of circulatig water path is changed into 1.0mm from 0.4mm in spray nozzle made of heat—resisting stainless steel. As a result, service life of welding gun increases by 4 times because of unblocking of circulating water.

Subject terms: electric arc welder argon—shielded arc welding welding gun good command of introduced technology

Yang Xianxun(28)

The Application of Shear—Butt Welder

Shear—butt welder for welded pipe below ∅114mm imported from abroad since 1980's are analysed. The property characteristics of a kind of shrar—butt welder which is composed of two shear—blade and a carbon—dioxide arc welder are introduced. The principal advantages of the welder are compact structure, handy operation, high automation and excellent welding quality. In this paper, srtucture sketch map, hydraulic system map and principal property parameters of the welder are given.

Subject terms: pipe welding machine shear butt welding machanical equipment technological property

Feng Shigong(31)

The Calculation of Forming Force, Rolling Torque and Motor Power of ERW Pipe

The new experience formulae have been deduced on the basis of analysis to previous experience formulae of forming force and rolling torque in longitunally welded pipe. The formulae could be used to get following date: forming force; rolling torque; transmission power; rolling force of horizontal roll; driving force of vertical roll; forming force of directive hoop roll. The application examples in ∅168×6,8,10,13 welded pipe production, in this paper, are also given.

Subject terms: pipe welding machine forming roll factors related to rolling process roll force rolling torque desing

Ren Hongcheng(41)

Design of the Conveyer of Spiral Welded Pipe

The function of the conveyer in spiral welded pipe mill is introduced in brief. The structure features of both types of conveyers, i.e. separatted and combined, are analysed, and examples of power selection of con-