

焊缝超声波探伤中缺陷性质的评估

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摘 要: 通过对超声波探伤中典型缺陷及其反射波特征和缺陷波形的分析, 结合缺陷的位置和焊接工艺, 给出了焊缝超声波探伤中缺陷的定性评估方法。

关键词: 超声波探伤; 焊缝; 缺陷评估

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超声波探伤对缺陷的定量有不同的方法, 但对缺陷的定性是比较困难和复杂的。笔者谈谈焊缝超声波探伤中常见缺陷的评估, 检出缺陷后, 应在不同的方向对该缺陷进行探测, 根据缺陷和反射波特征、缺陷波形, 结合缺陷的位置和焊接工艺, 对缺陷的性质进行综合评估。

1 声波反射和透射的基本原理

超声波探伤中缺陷波幅的高低反映缺陷的大小, 缺陷性质的评估主要依据波幅的高低和包络线变化等因素。下面简要介绍声波反射和透射的基本原理:

当声波 (声强为 I) 垂直入射到声阻抗不同的两介质、的大平面时 (如图 1 所示), 一部分入射波能量透射界面, 继续在介质 中传播, 为透射波 (声强为 I_2), 另一部分能量被界面反射回来, 仍在介质 中传播, 为反射波 (声强为 I_1), 根据能量守恒规律: $I = I_1 + I_2$

式中 I —入射声能;

I_1 —反射声能;

I_2 —透射声能。

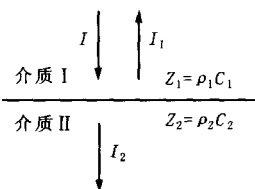


图 1 对大平界面垂直入射时的反射和透射

在实际探伤工作中常用反射波声压 (P_r) 与入射波声压 (P_o) 的比值表示声压反射率 r , 且有

$$r = P_r / P_o = (Z_2 - Z_1) / (Z_2 + Z_1)$$

式中 Z_1 —介质 的声阻抗;

Z_2 —介质 的声阻抗。

用透射波声压 (P_t) 与入射波声压 (P_o) 的比值表示声压透射率 t , 且有

$$t = P_t / P_o = 2Z_2 / (Z_2 + Z_1)^{[1]}$$

(1)若 $Z_1 > Z_2$, 声波大部分反射而小部分透射, 即大部分从介质 反射回去而小部分从介质 透射入介质 。对于含有非金属夹杂物的缺陷, 如夹渣等, 其声阻抗与钢声阻抗差异较小, 透射的声能已不能忽略, 缺陷反射波就相应降低。此种情况类似夹渣缺陷。

(2)若 $Z_1 \gg Z_2$, 声波在界面上几乎全反射而透射极少。通常含气体的缺陷, 如气孔、未焊透、未熔合和裂纹等, 其声阻抗与钢声阻抗相差很大, 可以近似地认为声波在这类缺陷表面产生全反射, 故可获得较高的缺陷反射波。此种情况类似气孔、未焊透、未熔合和裂纹缺陷。

2 缺陷和反射波的特征

2.1 气孔

(1)气孔的特征 气孔体积一般不大, 呈球形或椭球形, 气孔中含有气体, 一般产生于引弧和熄弧处。

(2)气孔反射波特征 反射率高, 波幅因球

形反射体所致,不会很高。波形为单峰,较稳定,探头稍一移动,波形即消失,从各个方向探测,可得到大致相同的反射波。单个气孔类缺陷的反射当量一般均小于同声程 $\phi 2$ 横孔。

2.2 夹渣

(1)夹渣的特征 一般呈体积状,表面不规则,夹渣类一般为非金属夹杂物。

(2)夹渣反射波特征 反射率低,波幅一般也不高。波峰为毛粗,主峰边上有小峰,探头移动时,波形变化明显,从各个方向探测时,反射当量各不相同。夹渣的反射当量一般也小于同声程 $\phi 2$ 横孔。

2.3 未焊透

(1)未焊透的特征 有一定长度,一般产生于引弧和熄弧处。未焊透的位置根据坡口形式,一般在焊缝中部、焊缝两侧和焊缝根部。

(2)未焊透反射波特征 反射率高,波幅较高。因为有一定长度和固定的位置,探头水平移动时波形较稳定;从焊缝两侧探伤时,能得到大致相同的反射当量。未焊透的反射当量一般大于同声程 $\phi 2$ 横孔。

2.4 未熔合

(1)未熔合的特征 有一定长度,一般产生于焊道与母材、焊道与焊道之间。未熔合的位置一般不在焊缝中间。

(2)未熔合反射波特征 反射率高,波幅较高。探头平移时,波形较稳定,从焊缝两侧探伤时,反射当量不同,有时只能从一侧探到。未熔合的反射当量一般大于同声程 $\phi 2$ 横孔。

2.5 裂纹

(1)裂纹的特征 有一定长度和深度,表面不平整。裂纹大多产生于应力比较大的部位。

(2)裂纹反射波特征 反射率高,当探测方向好时波幅极高。波形较宽,且有多峰出现,探头平行或垂直移动时,反射波连续出现,探头摆动时,多峰波交替出现最大值,摆动角度较大。裂纹反射当量一般大于同声程 $\phi 2$ 横孔。

3 缺陷波形

缺陷波形分为静态波形和动态波形。静态波形指探头不动时缺陷波的高度、形状和密集程度;

动态波形指缺陷反射波随着探头的运动而变化,是变化的缺陷反射波图形。

3.1 静态波形

缺陷内含物的声阻抗对缺陷反射波高度有较大的影响,气孔内含气体,声阻抗很小,反射波高;非金属夹渣声阻抗较大,反射波低。不同类型缺陷反射波的形状也有一定的差别,气孔表面较平滑,界面反射率高,波形陡直尖锐;夹渣表面粗糙,界面反射率低,同时还有部分声波透射入夹渣层,形成多次反射,波形宽度大并带锯齿。

单个缺陷与密集缺陷的区分比较容易。一般单个缺陷反射波是独立出现的,而密集缺陷反射波则是杂乱出现,且彼此相连。

3.2 动态波形

探头运动的基本方式有四种(左右移动、前后移动、定点转动和环绕运动),所以,动态波形也有四种形式。缺陷不同,其动态波形也不同,所以,根据动态波形可以评估缺陷的性质^[2]。将缺陷可归结为圆形缺陷(如气孔)、平直缺陷(如未焊透、未熔合等)和锯齿形缺陷(如裂纹)等,下面介绍三种典型缺陷的动态波形图(如图2所示)。

利用动态波形图可以评估缺陷的性质。探头左右移动,圆形缺陷(如气孔)与线形缺陷(如未焊透、未熔合、裂纹等)的反射波包络线特征有显著差别。对于前者,探头能移动的距离较短(不大于声束截面),对于后者,探头移动距离则基本上与缺陷等长。区别平直缺陷与锯齿形缺陷时,则主要看定点转动或环绕运动时的缺陷反射波包络线特征。对于平直缺陷,探头可转动角度小(一般小于 10°),而且波形陡直,下降速度快;对于锯齿形缺陷,探头可转动角度大(一般可达 20° ,最大可达 45°),波形下降缓慢,且有起伏,故在焊缝探伤中,常用定点转动和环绕运动来区别缺陷是裂纹还是未焊透、未熔合。

4 缺陷的形状和位置

气孔一般呈球形或椭球形,形状较规则,探伤过程中描绘出的形状为圆形或椭圆形,在焊缝中的位置不固定。夹渣的形状不固定,有一定的宽度,在焊缝中的位置不固定。未焊透、未熔合和裂纹都呈线状,具有一定的长度,未焊透一般在焊缝

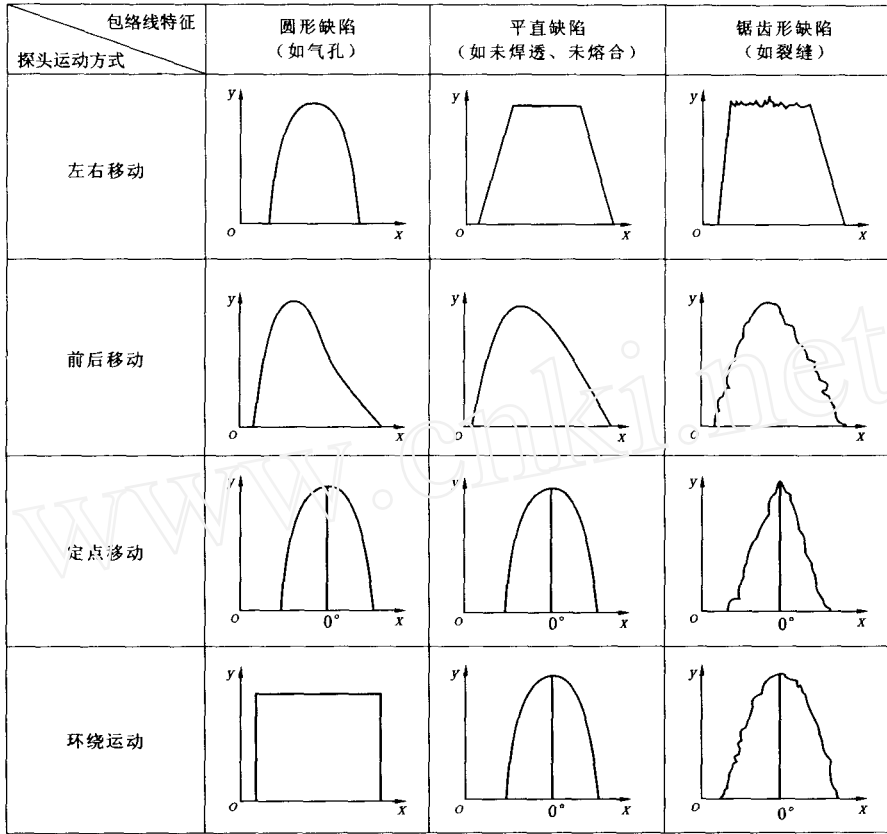


图 2 典型缺陷的动态波形图

中间位置,而未熔合一般在焊缝两边位置,裂纹出现的位置不固定。

5 结 论

对缺陷性质的评估归纳起来有以下要点:

(1)反射波的高低 夹渣反射波幅最低,气孔反射波幅次之,未焊透、未熔合、裂纹反射波幅最高。

(2)探头移动方式和缺陷包络线形状 左右移动时具有一定的长度为线性缺陷(如未焊透、未熔合、裂纹),而移动长度较短为球形缺陷(如气孔);定点转动和环绕运动时可以区分裂纹与未焊透、未熔合缺陷,定点转动和环绕运动时转动角度小,缺陷包络线波形陡直且下降速度快的为未焊透、未熔合缺陷,而转动角度大,缺陷包络线波形下降缓慢且有起伏的为裂纹缺陷。

(3)缺陷的形状 气孔大多数为球形或椭球形,形状较规则;未焊透、未熔合、裂纹一般呈线

状,具有一定的长度;夹渣形状一般较复杂,但具有一定的宽度。

(4)缺陷的位置 未焊透缺陷的位置一般靠近焊缝的中间,未熔合缺陷的位置一般靠近焊缝两边。

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ing and double faced forming of CO₂ gas metal - arc welding to welded pipe. Prepared welding process is practical and reliable and provides reference basis for the similar welding of welded pipe.

Key words: CO₂ gas metal-arc welding; single welding and double faced forming; welding process

Evaluation of Flaw Kinds During Welded Seam Ultrasonic Test

HUANG Lei, WANG Chang-an, NU Hu-qian

Abstract D: 1001-3938(2005)03-0049-EA

Abstract: It presents qualitative evaluation method of flaw combined with the position of flaw and welding procedure through analysis of typical flaws and its character of reflected wave as well as wave's forms of flaws.

Key words: ultrasonic testing; welded seam; flaw evaluation

Discussion on Cold Bending Forming Process of High Strength Structure Plate

ZHANG Wei-guo

Abstract D: 1001-3938(2005)03-0052-EA

Abstract: It analyzes physical property of high strength structure plate and its property of cold bend forming and puts forward related process improving measure in accordance with shelf module's cold bend defects of cold bending cracks, side wave, pouched wave, longitudinal bending, corner wrinkle and twist, etc. occurred during cold bend forming production.

Key words: high strength structure plate; cold bending forming process; shelf steel structure; cold bending effect

Preparing Pipe Additional Technical Specification for Crossing Changjiang of YI-CHANG Crude Oil Pipeline

ZHAO Wen-ming

Abstract D: 1001-3938(2005)03-0055-EA

Abstract: It introduces preparing principle and main target requirement of ERW pipe additional technical specification for Yizheng—Changling crude oil pipeline project in chemical composition, mechanical properties, geometrical dimensions, manufacturing process and test requirement combined with application of ERW pipe on this project and aimed to special work conditions of directional drilling crossing. It points out that to establish pipe additional technical requirement shall consider from practical demand and live up to rational matching harmony to gain final the best quality-value ratio.

Key words: ERW pipe; pipe crossing; additional technical specification; rational matching; quality-value ratio

Production Method Research to Internal Surface Hot Coating of Electric Welded Pipe

Translated and edited by L N Li-heng

Abstract D: 1001-3938(2005)03-0057-EA

Abstract: It presents a process method which it hot applies on the surface of strip first and then formed pipes with strips well treated. It indicates the method that it can adopt to compress 10% thickness after applying and make the coated layer pre plastic deformation as well as applies different thicknesses layers (i.e. gradually increasing applying thickness from centre line of strip) along with the direction of strip width during coating to increase the uniformity of coating layers after forming and improve anti-corrosion properties of coated layers by researching the properties and production process of this process method to produce two different sizes welded pipes.

Key words: electric welded pipe; coating; anti-corrosion property; production; process

Paint Mist and Yawp Pollution Control of Pipe Spray Paint Section

WANG Fu-mao, WANG Fa-zhan

Abstract D: 1001-3938(2005)03-0060-EA

Abstract: The pipe shall be protected with surface paint to prevent pipe rust during transportation for ensuring the quality of pipe during galvanized pipe production process. It analyses the composing and its harm of paint mist contamination and introduces design principle and process disposal of secondary filtering absorption clarifier. It puts forward yawp optimize design scheme of control spray paint fanner—assembly type double layers optimizing sound isolation cover. After disposal, contamination of paint mist and yawp at pipe spray paint section gained effective control, achieved project effect with drop yawp above 25 dB(A) and meet the requirements of environment yawp specification.

Key words: steel pipe; paint mist; yawp; pollution control

Pre Evaluation on Reliability of West-East Gas Transmission Pipeline

LUO Jin-heng, Zhao Xin-wei, Han Xiao-yi, Dong Bao-sheng, Huo Chun-yong

Abstract D: 1001-3938(2005)03-0062-EA

Abstract: The actual pipeline generally occur certain failure probability and reliability due to the indetermination of pipe quality, material property, internal pressure, accident load etc. It introduces a method that use failure evaluation chart and Monte Carlo method to calculate pipeline reliability and pre-evaluate the reliability of West-East Gas Transmission Pipeline by adopting target reliability abroad. The results show that the reliability of West-East Gas Transmission Pipeline fully meets requirements of specification whether it exist certain probability of defects failure inspection or not. In order to improve reliability of pipes, strict inspection shall be performed through manufacture of pipes and welding during construction of pipeline to avoid defects failure inspection caused by man.

Key words: west-east gas transmission pipeline; reliability; failure evaluation chart; pre-evaluation; monte carlo method