The ultrasonic detection of the large welded gear

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Abstract

The ultrasonic detection of large double-spoke welded gear is influenced by high technique request, the status of mechanism machining, detecting surface and other conditions. So we must do some redressal, design and provision on the detecting condition and detecting technics. Also we can do some experiments and validation.

This method pay attention to the following two points, one is the preparative of detecting condition, the other is the mensuration of instrument, detector and other technical estate. Based on this method, we analyse, judge and test the ultrasonic echo. This provide guarantee not only for the redressal and control of welded technics, but also for the detection and appraise of welded gear.

This method is proved to be feasible in the producing and detecting.

Key words: ultrasonic detection; large welded gear weld; double spoke; wave pattern analysis.

In recent years, with welding equipment's level of automation increasing, welding technology more and more maturity, In order to reduce the costs of design and manufacturing, increase the efficiency of produce, large welding gear is gradually being adopted by the design department. The main structural form what the gear now been adopted is spoke and double spoke, how to test its weld and assure the weld's quality are the key of whether the large weld is success. Now we discuss the ultrasonic detection of the large double spoke weld gear:

1. The technique demand and difficulty of the large double spoke weld gear

The structure of the large welding gear which our company produce show in figure 1, the gear's diameter is more than 2 meters, Its material is 16Mn, piece 3's material is 20# steel, the depth of piece 1 and 3's cliff is between 200 millimeter and 250 millimeter.

According to the design and technology requirements, There is need for dealing two pieces of 1, 2 and two pieces of 2,3 with ultrasonic testing at the standard ISO5817 class B. In order to ensure the gear wheel's strength and the hardness of the gear wheel surface, we do jointing after gear hobbing and heat treatment, so we can't do ultrasonic testing to the welding line from the outer round, and each weld can only do ultrasonic testing from one side of the spoke, this is the fact instance what the accessory test on line in use, thus increase the difficulty of do ultrasonic testing for the weld all-around, especially increase the difficulty of appraising the test result's dependability.

How to solve this problem, effectively guarantee the accuracy of test results and the welding

quality, make sure it can meet the requirements of the design technology, we have done calculation, analysis, experiment on every position of the weld to obtain their size and thickness, constituted a material testing scheme:

2. Conditions for detection

2.1 Before weld detection, first throw off the residual height in the outer surface of the weld. Because the existence of the weld residual high can influence the movement of the probe, it will make a diamond blind area appeared in the weld, the top of the weld cannot be detected, it can also influence the accuracy position of the crack.

2.2 According to the actual situation, an ultrasonic testing scheme was developed:

（1）use probe K1 and K2 to test from one side of the spoke;

（2）use macle probe to test from the surface of the weld.

3. The selection of instruments and probe

3.1 The selection of instrument

According to technical requirements of the drawings, double T-weld characteristics and the requirements of ISO5817, its work frequency should be between 0.5 and 20 MHz, the total attenuation ≥ 110dB, vertical linear error ≤ 3%, aclinic level error≤ 5%, dynamic range ≥ 30dB. According to this request, CTS-26-type ultrasonic flaw detector can meet the basic requirements.

3.2 The selection of probe

The thickness of spoke have 20mm and 40mm two standards. According to the standards requirements and data presentation, the best armor plate to detect the thickness is 4MHZ, probe K1 and K2, 4T14FG20Z、4T14FG40Z macle probe. But the homemade probe's frequency is 2.5MHZ or 5MHZ. After calculation, we use 5 MHZ, K1 and K2, wafer area is less than 8 mm×12mm，the probe of front ≤5mm, the macle probe 5T14FG20Z、5T14FG40Z.

3.3 The measurement of probe's angle of incidence and angle of refraction

(1) The mensuration of incident point

The veracity of the probe's incident point directly related to the accuracy of the crack orientation. Because the probe in the manufacturing process, the incident point of the probe often have a certain warp against the staff guage of the probe, and the probe will be wear and tear in the process of use, the position of the incident point will change. So before and during the use of probe, we must mensurate the probe's incident point renewedly to make sure that the orientation of the crack is exact. First locate the K probe on A side of the □W piece, adjust the depth, plus, attenuation snob of the ultrasonic instrument, so that the reflected wave of R100 can be shown in the sweep-screen machines, and the reflection reach the maximum position, then the position of the probe's incident point is in the center of the R100, measure the distance a from the front of the probe to the R100, so we can educe the distance between incident point to the front of the probe is 100-a.

(2) The angle of refraction measurement

Because of the influence by the manufacturing precision, material velocity, the wear and tear of the probe in the using process, the probe K value often have some deviations. We must mensurate the K value before using, otherwise the location of the defect will have a bias.

According to the formula: K = tg β, place the probe on the B side of ⅡW test block, adjust the knob of the equipment make the reflection of the waveform in Φ50 surface reach the highest wave: measured the distance C:

Formula: E0=c+b-35

EF=90-30

tgβ=EO/EF=K

According to the measured K values, correct the probe the same as the standard K value.

3. The production of DAC curve

a. Adjust the test range to 100mm, adjust the baseline scan according to the level;

b. Choose 20mm long transverse hole to be the first norm hole, place the probe on detection side of test block, place the sound bundle to the hole. Adjust the position of the probe, find the highest reflect wave of long transverse hole.

c. Adjust the plus or attenuator, so that the reflection wave amplitude is 50% of the screen full scale, the wave height is "benchmarks wave height"; the effective sensitivity of the detection system is 10 dB higher than the assessed sensitivity.

d. Adjust the attenuator, detect other horizontal holes in turn, find the highest wave reflection, record the wave reflection's relative amplitude dB;

e. Make the amplitude (dB) be longitudinal, the horizontal distance be abscissa, paint the recorded number on the plotting paper.

f. Connect the signed point into sleek curves, and extended to the entire scope of detection, paint a level between the recent detection point and the detection point o, this curve is the standard curve of the Φ3 horizontal hole DAC curve;

g. According to the standard requirements of the line sensitivity, paint waste-line, quantificational line, assessed line under the datum line, record the subarea of the amplitude.

4. detection method:

4.1 According to the requirements of the standard gear and the actual situation, introduce direct contact method which mainly use transverse wave detection and assistantly use longitudinal wave macle probe detection to do the ultrasonic detection. First use probe in Figure 2 position 1 with a first wave to test the middle and the bottom of the weld. Use the second wave to test the top of the weld in position 2. So we can satisfy the technique request in the vertical defect detection.

4.2 Place the probe on the weld surface to detect the transverse bug of the weld. Use macle probe detecting from the weld's surface, mainly detect the non-fusion, lack of penetration, crack, air hole, dregs and other defects.

5. The dependability of the root of the weld defects' ultrasonic detection and the judgement of the defects:

Because the double spoke weld gear use automatic submerged arc welding, it can easily form inner defects in the root in the role of gravity; the badness of welding technology will produce lack of penetration, non-fusion, crack, air hole, dregs and other defects. Therefore when do ultrasonic detection on the root of double spoke weld gear can appear inner concave reflection, lack of penetration, non-fusion, crack and other defect reflected waves. It can also appear air hole, dregs and other defect reflected waves. How to distinguish these reflect waves is the key of whether the double spoke weld gear double T-weld's ultrasonic detection is dependable.

a. concave reflect

Concave reflect is a bend surface of an arc; it is a convexity for ultrasonic, the reflect wave is emanative, the amplitude is lower(usually below the quantitative line sensitivity), the acoustic distance of Concave reflect wave is close to or slightly less than 0.5 times of the span acoustic distance. The distance between this defect and the bottom of the spoke is about 3 to 4mm;

b. lack of penetration reflect wave

When Ultrasonic detection is lack of penetration, the lack of penetration side will generate strong-angle reflection, its amplitude is higher. When the probe move along the uprightness of the weld, waveform is stable, when turning or swinging the probe, waveform disappear faster, the acoustic distance of lack of penetration reflect wave is nearly 0.5 times of the span acoustic distance.

c. non-fusion reflect wave

When the detect toot is non-fusion, the non-fusion side will generate strong-angle reflection, its amplitude is higher, its horizontal position is within the weld centerline. If it is the other side, its amplitude is lower, its horizontal position is without the weld centerline.

d. crack reflect wave

Crack is the most dangerous defect in the weld, it is usually produced in the heat-affected area of workpiece 1(gear) and a lateral fusion position in the root, it is similar to the on-fusion reflect wave, the difference is that the surface of the crack is devious, not smooth, the reflect wave bottom is wide and often have more apices, the wave crests are ups and downs.

e. slag defects reflect wave

When detecting the slag defects near the root, defect wave often appear before the weld contour wave. The amplitude is lower, when the probe swinging, the waveform disappear slowly, it often appear more apices, dynamic waveform is wide and serrated.

f. dense air hole

Dense air hole often appear in the middle and top of the weld, the echo signal is strong, when the probe scanning on both side of the weld, it can find the echo is the same, dynamic waveform have more apices.

6. The mensuration of the defect direction length

In ultrasonic detection, some defects are unable to accurately determine its character. Therefore, the defect direction length is become one of the important index assessing the weld's quality. In normal detection, weld gear defects can be detected from several directions by straight probe and diagonal probe, judge the defect direction length synthetically. But now we only do detection from one side of the spoke, error may exist between the mensuration of the defect direction length and the actual value. In order to reduce errors and unnecessary rework, the following two methods are used to ensure the accuracy of detection:

1) Minimize the influence the nature of the ultrasonic probe and the relative location do to the defect direction length. Suppose the beam half vertex is A, the acoustic distance is S, therefore the beam wide in S position is L1; when the length of the defect at S position is greater than or equal to L1, the direction length measured by 6dB method is close to the actual defect length; when it is less than L1, the result is greater, the windage is more greater when the length of the defect is smaller. Therefore, in actual detection, when the defects found, choose different probe angle to do detection, use 12dB method to measure the length if necessary, choose the average of the two methods;

2) As the odd height have been throw off, do turning or moving along different position of

the defect after discover defect, find the outspread direction of the defect. Measure the defect direction length according to outspread direction, thereby reduce the influence by defects form, direction, location.

According to the technics and the method, find many defects in the actual detection process, do cut open detection through diging the hardware, the actual detect is the same as the detection result. The ultrasonic detection method is feasible, it can effective control the jointing quality of the gear, raise the jointing level, accumulate valuable experience for the coming weld gear ultrasonic detection.