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Recommended practice for vibration stress relief on welding structure

焊接构件振动时效工艺参数选择及技术要求

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Recommended practice for vibration stress relief on welding structure

1 Scope

This Standard the recommended practice for vibration stress relief on welding structure, including the selection of technical parameters, the technical requirements and the method for evaluation of vibration stress relief effects.

This Standard applies to the vibration stress relief on fusion welding structures of carbon structural steel, low alloy steel, stainless steel, copper and copper alloys, titanium and titanium alloys.

2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For dated references, the subsequent amendments (excluding corrigenda) or revisions do not apply to this Standard, however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

JB/T 5925.2, *Machinery vibrating stress relief device – Part 2: Technical requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

exciting point

A point to which force is applied to a structure during vibration stress relief is called an exciting point.

3.2

support point

A position of a supporting structure which is chosen to provide vibration stress relief

a) the accuracy of steady speed can be controlled within ± 1 r/min;

b) it can plot a complete, detailed frequency sweep curve and multiple acceleration-time curves, on line or at the end;

c) the acceleration measurement system can be an attached part of the vibration stress relief device, or an independent measuring instrument.

5 Selection of technical parameters and technical requirements

5.1 Parameter determination criteria

Under general conditions, the vibration parameters shall be determined by analyzing and estimating the possible vibration modes within the excitation frequency of a structure based on the working conditions of the welding structure.

For a major structure or key structure, finite element analysis can be carried out for the dynamic stress under boundary conditions, in order to obtain the inherent frequencies and vibration modes of the structure within a certain range (16 Hz ~ 200 Hz) and locate the positions of support points, exciting points and vibration pick points.

5.2 Direct vibration

A structure can be vibrated directly within the excitation frequency range if responses can be excited.

5.2.1 Support of a structure

For the structure which can be vibrated directly, an elastic support and be placed at the node in accordance with the vibration mode obtained from analysis and estimation. Support points can be two, three or four.

The support of special structures stable.

5.2.2 Fixation of an exciter

An exciter shall be fixed rigidly at or near the peak of the resonant vibration modes of principal frequency; the place of fixation shall be smooth.

5.2.3 Fixation of vibration pickup

A vibration pickup shall be fixed far from the exciter, at or near a spot where it can reflect the maximum amplitude of the vibration mode of principal vibration mode, with its direction identical to the direction of vibration.

sweep method, or obtained using the frequency analysis method. After the relief frequency is found, select the frequency corresponding to 1/3 ~ 2/3 of its vibration peak value within the sub-resonant zone to start the vibration of workpieces.

During a span frequency sweep, the principal and additional frequencies are decided in accordance with the resonance peaks found; the support points, exciting points and vibration pickup points are adjusted in accordance with the vibration mode of the principal vibration frequency.

When the frequency analysis method is used, an exciter can be used to vibrate workpieces intermittently to obtain the inherent frequency of workpieces; and based on the principles of multiple vibration modes, the optimum frequency group is selected by automatic optimization.

5.4.5 Dynamic stress

The amplitude of dynamic stress shall achieve 1/3 ~ 2/3 of the working stress of a structure.

Dynamic stress can be estimated in accordance with the following equation:

$$(\sigma_b - \sigma_s)/3 \leqslant \sigma_d \leqslant \sigma_b/3 \quad \cdots\cdots (1)$$

where:

σ_d – the amplitude of dynamic stress;

σ_s – the yield strength of a material;

σ_b – the tensile strength of a material.

The control of dynamic stress amplitude is related to the degree of stress concentration. When geometry of the structure is uniform and the stress concentration factor of joints is small, the dynamic stress can be the upper limit value (σ_b/3); when the geometry of the structure is not uniform and the stress concentration factor of joints is large, the dynamic stress can be the lower limit value (σ_b - σ_s)/3.

5.4.6 Time of vibration

Under general conditions, the vibration stress relief on a welding structure includes three stages:

a) at the beginning stage (about 2 min ~ 3 min after starting vibration): the major parameters change rapidly and the residual stress of the structure also changes rapidly along with it;

b) at the medium stage: the changes of parameters and stresses tends to be slower;

The actual effects of vibration stress relief can be estimated in accordance with the changes of the *a-t* curve and the changes of the *a-n* curve before and after vibration, which are printed in real time during the process of vibration stress relief.

In one of the following cases, it can be decided that vibration stress relief is effective:

a) the *a-t* curve rises before becoming flat;

b) the *a-t* curve rises before descending and finally becomes flat;

c) the *a-n* curve has changes of single characteristics or combined characteristics after the resonance peak (such as rise, decrease, left shift and right shift of amplitude);

d) the *a-n* curve becomes concise and smooth after vibration;

e) the *a-n* curve has an increase of low amplitude peaks.

6.2 Actual measurement method

6.2.1 Residual stress measurement method

The blind hole relaxation method is recommended; the X-ray diffraction method can be used, or the magnetic method can be used if possible.

During the test using the blind-hole method, the thickness of the material at the testing spots shall be greater than four times of borehole diameter.

For each structure, two to three principal welds can be selected. The testing points for each principal weld shall not be less than three. The testing points shall be distributed at the centre or the root of the welds.

Use the average value of stress before and after vibration to calculate the reduction rate of stress, which shall be greater than 30%.

The difference between the maximum and the minimum stresses before and after vibration is used to evaluate the uniformity of stresses; the calculated value after vibration shall be less than the calculated value before vibration. For the maximum and minimum stresses, the principal stresses or longitudinal stresses of welds shall prevail under general conditions.

6.2.2 Dimensional accuracy stability test

The welding structures for vibration stress relief which are mainly subjected to dimensional stability testing, their dimensions shall be measured after vibration. The specific method of dimension testing shall be as follows:

Annex A

(Informative)

Description of applications of vibration stress relief

A.1 Vibration stress relief of other types of welding structures

This Standard prescribes a limit to the applicable scope of vibration stress relief, but the specifications of this Standard can be referred to for other types of joints or structures (e.g.: brazed structures using undermatching joints and diffusion welding structures) in vibration stress relief.

A.2 Stress concentration factor of welding joints

For the welding structures for which the vibration stress relief technique is used, select the types of joints which have a small stress concentration factor, which is generally not greater than 2.8. For the welding structures which have the welding joint design of significant stress concentration, including spot welding, plug welding, overlap welding, non-full penetration welding and so on, the maximum dynamic stress amplitude shall be limited in accordance with the increase ratio of their stress concentration factor.

A.3 Operating characteristics of a structure

Because it has no functions of dehydrogenation and material plasticity recovery in vibration stress relief, for the welding structures which have the requirements for embrittlement resistance, it is recommended that vibration stress relief is not used as the final aging treatment.

A.4 Combination of vibration stress relief and other processes

For the welding structures of long processing cycles, of which residual stress has effects on the processing quality, vibration stress relief can be one part of a compound process when the requirements for the elimination of stresses cannot be fully satisfied only by vibration stress relief:

a) vibratory welding + vibration stress relief;

b) vibration stress relief + thermal stress relief;

c) vibration stress relief + weld hammering or weld ultrasonic peening.

A.5 Vibration correction of a structure

A structure of excessive deformation shall be corrected before being subjected to

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