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# NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

# GB/T 38811-2020

## Metallic materials - Residual stress - Method of sound beam control

金属材料 残余应力 声束控制法

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## 1 Scope

China's national standard for measuring residual stress in metals by the sound beam control method. It specifies the terms and definitions, the principle and the equipment. The technique rests on acoustoelasticity: the speed of an ultrasonic wave in a metal depends slightly on the stress it is passing through, so measuring the time of flight with enough precision gives the stress along the beam path. The effect is small - a fraction of a per cent change in velocity for stresses near yield - which is why the method needs careful control of everything else that changes velocity, above all temperature and texture. What makes it worth the trouble is that it is genuinely non-destructive and measures through the thickness rather than only at the surface, which neither X-ray diffraction nor hole drilling can do. For welded structures, where the residual stress that matters is inside the joint, that is a decisive advantage.

This Standard specifies the principle, equipment, workflow, treatment effect comparison and control report for using a sound beam with a certain energy and directionality (elastic beam in a solid) to control the residual stress on the surface and inside of metal materials. This Standard is applicable to the on-site in-situ reduction and homogenization of the assembly and welding of large metal components such as metal containers, steel structures, pipelines, tracks, car bodies, aerospace cabins. The control of the surface and internal residual stress of other non-metallic sound-transmitting materials can also use it as reference.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 12604.1, Non-destructive testing - Terminology - Terms used in ultrasonic testing

GB/T 20737, Non-destructive testing - General terms and definitions

GB/T 32073, Non-destructive testing - Test method for measuring residual stress using ultrasonic critical refracted longitudinal wave

## 3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 12604.1 and GB/T 20737 as well as the followings apply.

3.1 method of sound beam control a method that injects a sound wave or elastic wave with a certain energy into the material in a certain direction along a certain direction, so as to reduce and coupling. Ensure that sound waves can be effectively and directed into the interior of the processed material. At the same time, the surface of the exciter shall not cause any damage to the surface of the material.

6.3 Selection of control part The control position of the residual stress of the material shall be negotiated by related parties, in accordance with GB/T 32073. Use non-destructive testing method to determine the size, direction and gradient distribution or concentration area of residual stress inside the component.



### 6.4 Control mode

6.4.1 Overview The control modes are divided into four categories: vertical incident body wave mode, oblique incident guided wave mode, oblique incident surface wave mode, oblique incident array focus mode. When the sound beam is controlled, the control mode can be selected according to the actual situation.

6.4.2 Vertical incident body wave mode Place the sound beam exciter vertically on the surface of the material. The axis of the sound beam is consistent with the surface normal of the material. Longitudinal sound beam is reflected back and forth in the thickness direction with boundary. The acoustic mode converses for multiple times at the interface to form a superposition wave of longitudinal and transverse waves. Material point is in irregular and forced fluctuation. It can reduce and homogenize the residual stress in any direction in the material and in the area near the sound beam incidence. This mode is mainly used for the reduction and homogenization of residual stress on the surface and internal concentrated areas of the material. The schematic diagram of the control mode of the vertical incident body wave is shown in Figure 1.

6.4.3 Oblique incident guided wave mode Place the sound beam exciter on the surface of the waveguide component at a certain angle. The axis of the sound beam and the tangent plane direction of the material surface maintain a certain angle alpha. Meet the conditions of guided wave incidence. The control mode of oblique incident guided wave is shown in

Figure 2. The direction of the arrow indicates the main direction of stress in the component. This angle depends on the excitation wedge material, the thickness or diameter of the waveguide component material, and the elastic constant. Usually choose the incident angle and frequency of the low-order symmetric or asymmetric mode of the guided wave. Guided waves propagate in the form of superposed waves of longitudinal and transverse waves in waveguides such as plates, tubes, columns. Material point is in irregular and forced fluctuation. It 4 - Regulated component; alpha, beta - incident angles of sound beam. Figure 4 -- Oblique incident array focus mode

6.5 Control process During the control process, the actuator wedge shall be firmly and tightly attached to the material surface; coupling contact force remains stable during control. The specific operations of the control process are as follows:

a) The electrical connection of the working system is intact and meets the equipment specifications and requirements;

b) Place the exciter on the surface of the material according to the required control mode. Apply couplant evenly on the end face of the exciter. Use vacuum, magnetic or mechanical clamping to clamp the exciter on the surface of the component stably. Ensure that the end surface of the exciter and the surface of the component are closely fit and coupled;

c) After checking the working system connection, turn on the system equipment and start working. Set the exciter to work at the natural frequency. According to tooling compaction state and incentive effect, properly adjust the optimal frequency and working time of the exciter, to make the exciter always keep in the best working condition;

d) After the residual stress control process is over, turn off and organize the control equipment. Remove the clamping fixture. Clean the surface of the component and the couplant on the end face of the acoustic beam exciter;

e) Record process parameters.

## 7 Treatment effect comparison

7.1 The parameter value and gradient distribution of normal (normal) stress and cut (shear) stress have an important impact on product quality and performance. Generally, there shall be clear requirements and clear marks in the stages of structure design, manufacturing process, combined assembly, inspection and testing, and safe service.