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Specification for Shaft Forgings for Hydroturbines and Hydrogenerators

水轮机、水轮发电机大轴锻件技术条件

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Table of Contents

Specification for Shaft Forgings for Hydroturbines and Hydrogenerator

1 Subject Contents and Applicable Scope

This Standard specifies the technical requirements, inspection rules, test methods, certificates of conformity, and marking of the shaft forgings (including welded shafts, hereinafter referred to as forgings) for hydroturbines and hydrogenerators.

This Standard is applicable to the ordering, manufacturing and inspection of shaft forgings for hydroturbines and hydrogenerators.

2 Normative References

GB 222 Method of Sampling Steel for Determination of Chemical Composition and Permissible Variations for Product Analysis

GB 223 Methods for Chemical Analysis of Iron, Steel and Alloy

GB 228 Metallic Materials – Tensile Test

GB 229 Metallic Materials – Charpy (U-Notch) Impact Test

GB 11345 Method for the Manual Ultrasonic Testing and Classification of Testing Results for Steel Welds

JB 1581 Ultrasonic Testing Method for Rotor and Shaft Forgings of Steam Turbine and Turbine Generator

JB/ZQ 6101 Magnetic Powder Inspection Method for Forged Steel Parts

3 Ordering Requirements

3.1 The purchaser shall specify the forging grade, steel grade, standard number, required supplementary test items in the ordering contract.

3.2 The purchaser shall provide the size and delivery pattern of forging indicating the location of test sample for mechanical properties.

The residual stress value (absolute value) of the forgings shall not exceed 39MPa.

NOTE: When there is no major change in the process, the residual stress test may not be performed.

4.5 Non-destructive test

4.5.1 Forging surface

The forging surface shall be free of the visible cracks, folds, or other appearance defects that affect the use. The local defects can be removed; but the depth of removal shall not exceed 75% finishing allowance. For the general defects exceeding the finishing allowance, repair welding is allowed. If there are serious defects, the repair welding shall be conducted with the consent of the purchaser. After repair welding, the following treatment and inspection are required.

4.5.1.1 After the repair welding, the supplier shall perform the stress relief treatment.

4.5.1.2 When taking the ultrasonic flaw detection and pickling (or magnetic particle) inspection, there shall be no cracks.

4.5.1.3 In the repair welding zone, the hardness difference with base metal shall not exceed 50HBS.

4.5.1.4 Provide inspection records.

4.5.2 Center hole

The supplier inspects the center hole of forging with naked eyes or the sneak instrument, the inspect results shall conform to the following provisions:

a. The surface of the center hole shall be free of cracks, looseness, shrinkage hole residue;

b. Single, discrete defects with length no more than 8mm are allowed to exist (when the defect spacing is no less than 5 times of the length of the larger defects, it can be called the single, discrete defect);

c. Large-area aggregated defects shall not exceed 20 in any area of 100cm^2 with the length of 1.5~3mm;

d. Spot-like defects that are distributed in chains are not allowed to exist;

e. When the defect exceeds the standard, the two parties shall negotiate.

4.5.3 Pickling or magnetic particle inspection

When the forging is inspected by pickling or magnetic particles, there shall be no white

spots or cracks.

4.5.4 Ultrasonic flaw detection

4.5.4.1 When taking the ultrasonic flaw detection on the outer surface of the forging, the results shall conform to the following provisions:

a. No white spots, cracks, shrinkage holes, and the like defects are allowed to exist;

b. Defects with an equivalent diameter of less than 5mm are not counted;

c. Dense defects with equivalent diameter of 5mm and above are not allowed to exist;

d. Single, discrete defect with equivalent diameter of 6~10mm is allowed to exist; but the spacing between two adjacent defects is not less than 5 times of the diameter of the larger defect.

4.5.4.2 The weld seam of welding shaft shall be carried out ultrasonic flaw detection. The results shall conform to the following provisions:

a. Any form or orientation of cracks are not allowed to exist;

b. Failed fusion or incomplete welding penetration of any part is not allowed to exist;

c. Defects with an equivalent diameter of less than 5mm are not counted;

d. Single slag and pore with equivalent diameter of no more than 10mm are allowed to exist; but the spacing between two adjacent defects shall be no less than 5 times the diameter of the larger defect;

e. Strip defects with equivalent diameter no more than 10mm are allowed to exist; but the spacing between two adjacent defects is no less than 50mm (the strip defect indicate the one with a ratio of length to with equal to or greater than 3).

f. In the weld seam with length of 8 times of wall thickness, the total length of the continuous defects shall not exceed the welding wall thickness.

4.6 Size, tolerance and roughness

4.6.1 The forgings shall be processed in accordance with the size, tolerance, roughness requirements specified in the delivery drawings of the purchaser.

4.6.2 The center hole surface of the forging shall be fine-bored at the supplier site till the surface roughness R_a of 3.2μm.

5.2.1.1 When the two ends of the forging with or without flange, the supplier shall take sample from the rise end of the forging; while the purchaser shall take sample from the nozzle end. When one end has flange, both supplier and purchaser shall take samples from the flange end or shaft head end.

5.2.1.2 For axial sample, when taking sample from flange end, drill 4 tensile samples and 4 impact samples at the flange bole hole or corresponding positions. When taking sample from the shaft head end, take 2 tensile samples and 2 impact sample from the 1/2 wall thickness of the forging with center hole, or at the 1/3 radius from the surface.

The tangential sample can be cut on the residual stress ring of the flange or at the corresponding part. Take 2 tensile samples and 2 impact samples at the symmetrical position of the ring.

When taking the mechanical property sample of the welded large shaft by electroslag welding, cut the sample on the welding test plate of the large shaft forging; take 2 tensile samples and 2 impact samples.

5.2.2 Test methods and sample size

5.2.2.1 Tensile test method shall be performed as per GB 228; the sample is the standard one with diameter of 10mm, and gauge length of 50mm.

5.2.2.2 Impact test method shall be performed as per GB 229; the sample is the Meister one with size of 10mm×10mm×55mm.

5.3 Residual stress test

5.3.1 After the final heat treatment, the forging shall be carried out residual stress test; use the ring-cut method or ring-shaped core resistance strain method to measure the residual stress.

5.3.2 When using the ring-cut method, if the flange diameter is less than 1250mm, and two ends with flange, then the supplier shall cut ring at the rise end, while the purchaser shall cut ring at the outer circle surface of flange end of the nozzle end. If one end with flange, then both sides cut ring at the outer circle surface of the flange end.

When the flange diameter is greater than 1250mm, cut ring from the outer circle surface on the shaft head end or at the inner hole surface; or cut ring at the inner hole surface on the flange end. The cross-section size of the ring is 25mm×25mm.

5.3.3 Calculate the residual stress by the method of measuring the average deformation of the ring before and after cutting, the calculation formula is as follows:

$$\sigma_t = E\ \delta / D$$

6.2 Certificate of conformity

When delivering, the supplier shall provide certificate of conformity to the purchaser. The certificate of conformity shall contain the following contents:

a. Ordering contract number;

b. Ordering drawing number;

c. Melting furnace number;

d. Forging card number;

e. Results on chemical composition analysis;

f. Results on mechanical property test;

g. Results on non-destructive test (If necessary, provide the defect layout drawings);

h. Test report of center hole;

i. Main process parameters of the final heat treatment (when required by the purchaser, report the main process parameter of post-welding heat treatment and welding specification for welding large shaft, as well as the qualification of the welding personnel).

6.3 Police on return of products

After the acceptance of the supplier on the forgings, if the purchaser discovers the impermissible defects during the processing and reinspection period, the purchaser shall notify the supplier timely, and the two sides shall settle the problem through negotiation.

7 Marking and Package

The supplier shall mark the contract number, smelting furnace number, forging card number on the position of forging equivalent to the nozzle end of the steel ingot; and use white paint to circle.

After the center hole of the forgings are checked qualified, the surface of the inner hole shall be coated with anti-rust oil.

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