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ALLOY STEEL FORGINGS FOR STEAM TURBINE ROTORS

GR: 23 Cr Mo Ni W V 88

1.0 GENERAL :

This specification governs the technical requirements of steam turbine rotors forged out of steel grade 23 Cr Mo Ni W V 88.

2.0 APPLICATION :

Steam turbine rotors for combined HP/LP cylinder.

3.0 CONDITION OF DELIVERY :

The rotor forgings shall be supplied in heat treated and rough machined condition. The heat treatment shall be done in such a way so that the mechanical properties as per the drawing indicated in Purchase Order are achieved.

4.0 COMPLIANCE WITH NATIONAL STANDARD :

There is no national standard covering this grade of material. However, guidance is taken from Siemens AG Specification No.0-2811-0000-21 (Feb.95).

5.0 DIMENSIONS AND TOLERANCES :

The rotor forgings shall be supplied to the dimensions shown on the ordering drawing. The tolerance shall be as follows unless otherwise specified in the drawing/order.

Upto 500 mm	+ 1 mm
Over 500 mm	+ 2 mm

6.0 MANUFACTURE :

The steel shall be made from basic electric furnace and shall be subsequently refined by Vacuum Carbon Deoxidation (VCD) or Electro Slag Refining (ESR) process. Any other process (like CAB etc.) are acceptable subject to prior approval of BHEL.

Sufficient discard from Top and Bottom shall be made from the ingot to ensure freedom from piping segregation and other injurious defects. The forging process adopted shall ensure homogeneity of material throughout the section. It is important to maintain the actual centre of the forging, as far as possible identical with the centre of the ingot. Press straightening, if necessary, may be performed before heat-treatment.

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The initial ingot dimensions, general forging process and manufacturing plan shall be submitted alongwith the offer for approval of BHEL.

After heat-treatment, the forging shall be rough machined, to the dimensions and surface finish shown on the ordering drawing.

The material as per this specification shall be supplied by the manufacturers who are having complete in-house steel melting, refining, hot rolling/forging/blooming, etc., heat treatment and testing facilities.

7.0 **CLOCKING SYMBOLS :**

Before heat-treatment, clocking symbols 3-6-9-12 shall be stamped on the rotor. If the symbols are transferred during manufacture, they shall be restamped in the same clockwise position. The clocking symbols shall be used for reference purposes in recording the position of defects, etc. the clocking symbols shall be encircled with oil paint for easy identification.

8.0 **CHEMICAL COMPOSITION :**

The chemical composition of the material in ladle analysis shall be as follows :

Element		C	Si	Mn	Cr	Mo	Ni	W	V	P	S	Al (total)
VCD Pro- cess	Min	0.21	-	0.65	2.05	0.80	0.70	0.60	0.25	-	-	-
	Max	0.23	0.10	0.75	2.15	0.90	0.80	0.70	0.35	0.007	0.007	0.008
ESR pro- cess	Min	0.21	-	0.65	2.05	0.80	0.70	0.60	0.25	-	-	-
	Max	0.23	0.20	0.75	2.15	0.90	0.80	0.70	0.35	0.007	0.005	0.010

For CAB process Si and Al are permitted upto 0.15 & 0.010 max. respectively. All other elements levels shall be similar to VCD Process.

Small deviations in chemical composition are permissible only after approval from BHEL, provided that the specified properties are not impaired.

8.1 Tramp Elements : The content of tramp elements such as Cu, As, Sn, Sb shall be low enough to avoid temper embrittlement. The values actually obtained shall be reported in the test certificate for the information of BHEL.

9.0 **HEAT TREATMENT :**

9.1 The rotor forging shall be hardened and tempered in vertical condition using suitable heat treatment process parameters, so as to achieve the best possible strength and toughness characteristics meeting the requirement of this specification and ordering drawing.

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9.2 Lowest Residual stress must be aimed with proper tempering cycle, including cooling rates from tempering temperatures.

9.3 The residual stresses measurement in the forging shall be carried as per BHEL Corporate standard AA0850150. In lieu of BHEL standard AA0850150, residual stress measurement may be carried out by ‘Blind hole method’ as per ASTM E 837. However all other conditions of AA0850150 such as location of tests, acceptance criteria, etc remain same. The residual stresses shall not be more than 60 N/mm² at any point on the surface.

9.4 In case the required properties have not been obtained, reheat-treatment of the forging is to be carried out. The maximum number of reheat-treatments permitted are two. However, retempering is not considered as reheat treatment.

9.5 All heat treatments including stress relieving shall be performed in vertical condition.

10.0 **SELECTION OF TEST SAMPLES :**

10.1 The location of the test pieces shall be shown on the ordering drawing. The test samples shall not be removed before heat treatment.

10.2 The test samples are to be clearly identified with identification number. The association with the forging is to be conformed by BHEL nominated agency/representative. The balance material shall be delivered alongwith the forging.

10.3 **Axial Core:** An axial core of ≥ 60 mm dia. must be taken from the LP side journal area of the rotor. The position of the axial core follows from the ordering drawing. Independent of the drawing data, the rotor is to be placed in the forged block in such a way that the axial core lies at the top end of the ingot. The clearance for drilling axial trepanned core shall be given by BHEL depending upon the pattern of results of tangential test specimens, ultrasonic test and residual stress measurements.

Axial core shall be clearly identified so that their original position on the rotor are correlated.

11.0 **MECHANICAL PROPERTIES :**

11.1 The mechanical properties, when tested on the tangential test pieces shall conform to the following at room temperature.



	Tensile strength N/mm ² Max.	0.2% proof stress N/mm ²	% Elongation L = 5d min.	% Reduction in area min.	Impact strength J. min.
HP part	830	600-680	15	40	80
LP part	860	630-710	15	40	120

Note: 1. Refer ordering drawing for applicable mechanical properties given in the above table.

2. Tensile test shall be carried out as per IS:1608 or any National standard.

3. Impact test shall be carried out as per IS:1757 ISO-V notch or any National standard. The minimum impact strength value specified above is the average of three samples at the same location. Only one value is permitted below the specified min. value, but in no case shall be lower than the 2/3 of the same. All values shall be reported in test certificate.

4. The tangential ring must marked clearly with code No. The matching with the forging must be confirmed by the BHEL representative through his stamp., the rings must be separated from rotor forging and delivered with the forging.

T: Tangential test piece

Q: Radial test piece

11.2 Axial Core: The following properties shall be obtained on the axial core samples for the LP part.

0.2% proof Stress : 630 N/mm² Min.

Impact Strength : 80 J Min. at Room Temperature
(Average of 3 samples) : (in Radial direction).
ISO-V notch

FATT : + 25°C Max. (in Radial direction).

11.3 Whenever the axial core is extended up to the LP side of the rotor body, the following properties shall be achieved in the rotor body area. (refer ordering drawing)

0.2% Proof Stress : 630 N/mm² Min.

Impact Strength : 70 J Min. (in Radial direction)
(ISO-V notch, Average : at Room Temperature.
of 3 samples)

FATT : + 35°C Max. (in Radial direction).



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12.0 NON-DESTRUCTIVE TEST :

12.1 Ultrasonic Test: Ultrasonic test and evaluation shall be carried out as per BHEL Corporate standard AA0850106.

12.2 The axial bore hole after extracting the axial core, must be subjected to a magnetic crack test as per BHEL Corporate standard AA0850106. The findings shall be reported to BHEL for acceptance.

13.0 THERMAL STABILITY TEST :

If mentioned in the drawing or purchase order, Thermal Stability test shall be carried out according to BHEL standard AA0850152.

14.0 FIRST PIECE QUALIFICATION TESTS:

Whenever the supplies are made for the first time to BHEL, the requirements of BHEL specification HY0800099 shall also be applicable in addition to this specification. However based on the past experience of the supplier, BHEL may decide to waive off this requirement.

15.0 INSPECTION AT SUPPLIER'S WORKS:

BHEL representative shall have all reasonable facilities offered to him, at any time, by the supplier to satisfy himself that the material is being furnished in accordance with this specification. The representative shall have free access at all times while the work on the contract is being performed, to all parts of the manufactures works.

16.0 TEST CERTIFICATES:

16.1 Five copies of test certificates giving the following details shall be furnished.

- a) HY 19480 Rev.01
- b) BHEL order No.
- c) Item description and Drawing No. of the forging.
- d) Supplier's Name.
- e) Melt No. and Forge No. (Steel making and Refining processes)
- f) Results of chemical analysis alongwith trace elements.
- g) Results of Mechanical Tests & FATT.
- h) Results of residual stresses.
- i) Report of ultrasonic testing giving details of probe type and size, frequency, sensitivity, sketch showing the areas covered etc.
- j) Ingot dimensions, forging sequence and details of heat treatment cycles followed.
- k) Results of thermal stability test, if called for in the drawing/ purchase order.

16.2 The certificate shall be attested by chief of inspection/chief metallurgist of the supplier and BHEL representative.

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17.0 **MARKING :**

The following details shall be punched clearly on one end of the forging.

- a) HY 19480 Rev.01
- b) Forging No. and Melt No.
- c) Drawing No.
- d) Manufacturer's Stamp
- e) BHEL Inspector's stamp
- f) Clocking symbols.
- g) Top and Bottom sides of ingot

18.0 **PACKING AND TRANSPORTATION :**

Rotor forgings shall be properly protected from corrosion and damage during transit, journal portions shall be protected with anti-corrosive compound.

19.0 **REJECTION AND REPLACEMENT:**

In the event of any forging proving defective in machining, testing, erection and operation such forging shall be rejected notwithstanding any previous acceptance. The supplier shall replace the rejected forgings at his own cost.