Expression of Interest

For

"Review and Vetting of Design of Dissimilar Metal Weld Joint on Rotors and Casings of HP and IP Turbine of an Advance Ultra Super Critical Steam Plant"

Document No BHEL/AUSC/STE/TM/EOI/P2/01

BHARAT HEAVY ELECTRICALS LIMITED
HEAVY ELECTRICAL EQUIPMENT PLANT
HARIDWAR-249403, INDIA

1) Introduction

Bharat Heavy Electricals Limited (BHEL) is a leading engineering and manufacturing enterprise in the field of power generation & transmission, defense, transportation, oil & gas, renewables etc. BHEL is India's largest power generation equipment manufacturer. The company has more than 50 years of experience in the field of power equipment generation manufacturing with capacity ranging up to 800 MW.

As a part of Govt. of India initiative, BHEL is currently involved in the design development of an 800 MW Advanced Ultra Super Critical (AUSC) steam turbine with steam parameters in the range of 310 kg/cm^2 pressure and 720 deg. C temperature. This is a first of its kind effort as there is no precedence for a steam turbine plant with such advanced parameters and scale that exists across the world.

Ferritic steels exhaust their capability in this temperature range, hence use of Nickel based alloy is necessary. In order to keep the overall costs down and keeping in mind current manufacturing capability for Nickel based alloy components, welded turbine rotors and casings have been employed. Rotors have Dissimilar Metal Weld Joint (DMWJ) between Alloy 617 (M) and 9-10% Chrome steel forgings. Similarly HP and IP casings have dissimilar metal weld joint between Cast Alloy 625 (M) and 9-10 % Chrome steel castings.

For the purpose of validation of design of dissimilar weld joint in rotor and casings of HP and IP turbine, BHEL intends to engage consultancy organization or a team led by a lead Consultant in collaboration with suitable partners as deemed necessary (Lead Consultant having the prime responsibility of coordination with other experts as needed) in line with the broad scope detailed ahead, which is a preliminary outline of the work envisaged, and shall be finalized after detailed discussions further on.

2) Present Expression of Interest

For the purpose of design of dissimilar metal weld joint of welded rotors of HP and IP turbine of AUSC steam turbine, BHEL intends to technically shortlist Institution

or Consultancy Organization of International Repute based on this EOI.

BHEL shall receive applications pursuant to this EOI in accordance with the terms set forth herein, as modified, altered, amended and clarified from time to time by BHEL, and all applications shall be prepared and submitted in accordance with such terms on or before the date specified in this EOI.

3) Scope of Work for Prospective Institution/Consultancy Organization

Scope of work for design review has been described in Annexure-A.

4) Selection of Prospective Institution/Consultancy Organization

Based on the information provided under this EOI, the prospective institutions/consultancy organizations shall be technically shortlisted (ref. Annexure-C). The short listed institutions/consultancy organizations will further be evaluated on the basis of terms and conditions defined in the enquiry.

Pre-bid clarification meeting shall be held with the short listed parties regarding scope, confidentiality requirements and deliverables.

5) Brief Description of EOI Process

The interested prospective institution/consultancy organization shall ensure that its response in the form of a signed letter comprising the application as per format enclosed at Annexure-B and details requested as per Annexures-A & C of this EOI along with the information and data required as per attachments and supporting documents thereof, is received by BHEL on or before 31 Oct 2019. Alternatively, a scanned signed copy of the EOI may be sent by e-mail as advance copy by 31 Oct 2019, to be followed by original signed copy which should reach BHEL within 7 days of e-mail communication.

The response shall necessarily be accompanied with details of institution/consultancy organization's background, along with information required

as per Annexure-A&C. The responding prospective institutions/consultancy organizations on submission of their response can be contacted / invited for further discussions.

The response may be sent at the following address:

Sr. Dy. General Manager
Steam Turbine Engineering (STE-TM)
Bharat Heavy Electricals Limited
HEEP, Ranipur, Haridwar-249403
Uttarakhand, India
Phone: +91-1334-284237
Email: mbatrani@bhel.in

Any request for further information or clarification on the EOI document may be sent by mail to the address mentioned above. BHEL may respond to the queries raised/clarifications sought to the best of its ability. BHEL at its discretion may extend the due date for submission of EOI and the decision of BHEL in this respect would be final and binding on the respondents.

EOI submittals should be in English. Duly authorized representative shall sign on each page of the documents. EOI should be prepared in such a way so as to provide a straight forward, concise description of applicant's capabilities.

If at any time during the evaluation of EOI, BHEL requires any clarification on the documents submitted by the prospective parties, it reserves the right to request a clarification so as to complete the evaluation.

6) Miscellaneous

Right to accept or reject any or all applications

Notwithstanding anything contained in this EOI, BHEL reserves the right to accept or reject any application and to annul the EOI process and reject all applications, at any time without any liability or any obligation for such acceptance, rejection or annulment, and without assigning any reasons therefore. In the event that BHEL

rejects or annuls all the applications, it may, at its discretion, invite all eligible institutions/consultancy organizations to submit fresh applications.

BHEL reserves the right to disqualify any applicant during or after completion of EOI process, if it is found there was a material misrepresentation by any such applicant or the applicant fails to provide, within the specified time, supplemental information sought by BHEL.

BHEL reserves the right to verify all statements, information and documents submitted by the applicant in response to the EOI. Any such verification or lack of such verification by BHEL shall not relieve the applicant of his obligations or liabilities hereunder nor will it affect any rights of BHEL.

Governing Laws & Jurisdiction

The EOI process shall be governed by, and construed in accordance with, the laws of India and the Courts at New Delhi (India) shall have exclusive jurisdiction over all disputes arising under, pursuant to and/or in connection with the EOI process.

Annexure-A

Scope of work for Design Review

BHEL is currently involved in the design development of an 800 MW Advanced Ultra Super Critical (AUSC) steam turbine with steam parameters in the range of 310 kg/cm^2 pressure and 720 deg. C temperature.This is a first of its kind effort as there is no precedence for a steam turbine plant with such advanced parameters and scale exist across the world.

Ferritic steels exhaust their capability in this temperature range, hence use of Nickel based alloy is necessary. In order to keep the overall costs down and keeping in mind current manufacturing capability for Nickel based alloy components, welded turbine rotors and casings have been employed. Rotors have dissimilar metal weld joint (DMWJ) between Alloy 617 (M) and 9-10% Chrome steel forgings. Similarly HP and IP casings have dissimilar metal weld joint between Cast Alloy 625 and 9-10 % Chrome steel castings.

For the purpose of validation of design of dissimilar weld joint in rotor and casings of HP and IP turbine, BHEL intends to engage an external expert in line with the broad scope detailed ahead, which is a preliminary outline of the work envisaged, and shall be finalized after detailed discussions further on.

1. Configuration and DMWJ Details

The following section gives a brief description of configuration of HP turbine and IP turbine with details and location of dissimilar metal weld joint in casing and rotor of HP turbine and IP turbine

1.1 HP Turbine and details of HP Casing, HP Rotor and DMWJ

HP turbine of AUSC design consists of double casing construction with a single flow HP rotor. Both the casing as well as rotor feature welded construction. HP inner casing (*Figure 1*) is a casted bimetallic welded construction. Inlet portion, which will be at elevated temperature, is made of cast Alloy625M and portion towards exhaust is made of 10% Cr cast steel (GX12). There is a dissimilar metal weld joint between these two materials.

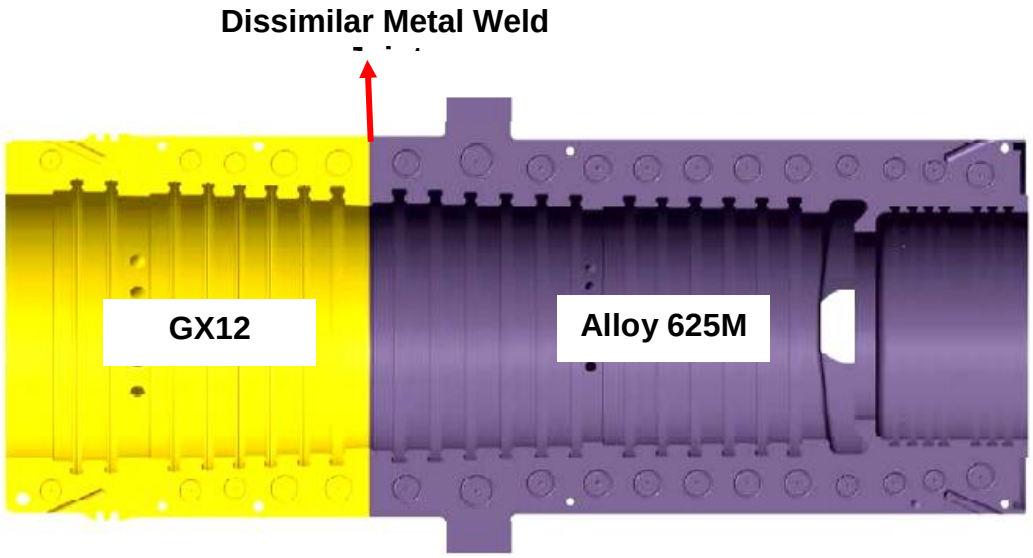

Figure 1: Cut Section view of IP inner casing

HP rotor (*Figure 2*) also features a bimetallic welded construction. It consists of two DMWJ's one in flow path and the other outside of flow path in the balance piston area. Nickel based forged material Alloy617M will be used in elevated temperature zone of rotor and forging of 10% Cr steel (X12) in lower temperature zone.

Each of these two weld joints may be considered as consisting of two areas at the location of joint. One is the weld cavity consisting of parent metal on both the sides of joint in Alloy 617M as well as Ferritic part. Another is the area where weld metal is deposited between the metal parts of Alloy 617M and X12 (weldment area) including buttering layer and Heat Affected Zone. BHEL team has carried out analysis of weld cavity as part of rotor design analysis and design validation/optimization of cavity has been done to the best of their knowledge. In the weld deposit area, the basic configuration of the weldment has been provided by consortium partner having expertise in welding technology. The weldment area has also been included in the rotor mechanical strength analysis with certain assumptions and stress numbers are generated through Finite Element Method (FEM). Consultant to decide stress assessment criteria and post processing of stress numbers.

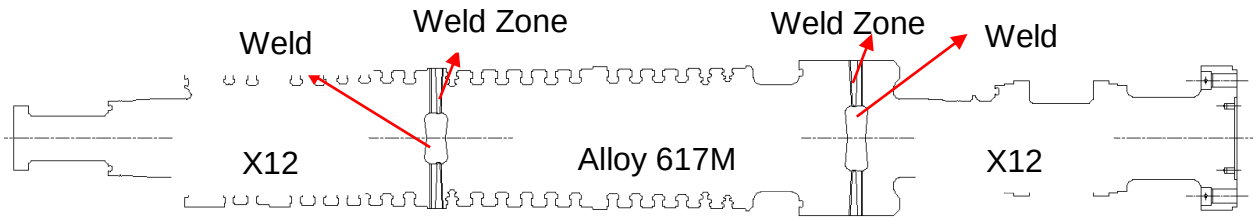

Figure 2: Axisymmetric section of HP rotor with DMWJ

1.2 IP turbine and details of IP Casing, IP Rotor and DMWJ

IP turbine of AUSC design consists of double casing construction and a double flow IP rotor. Both the casing as well as rotor feature welded construction

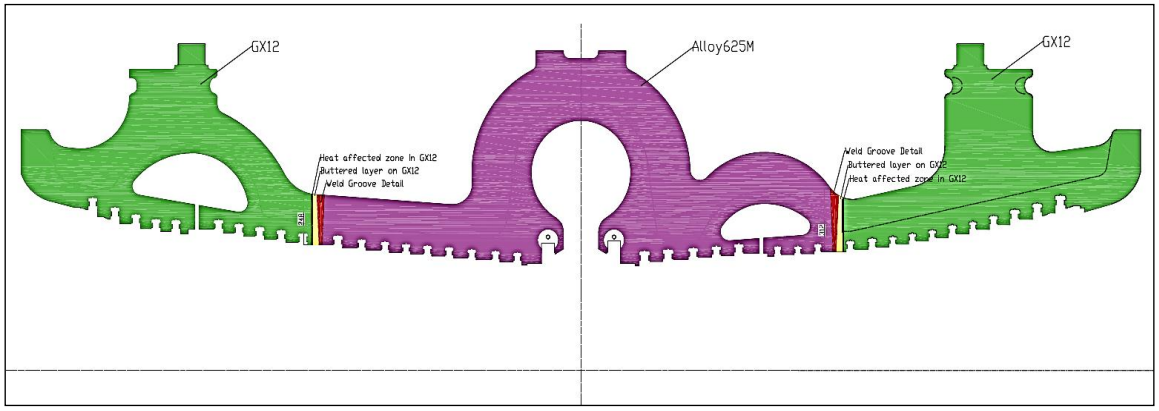

Figure 3: Cut Section view of IP inner casing

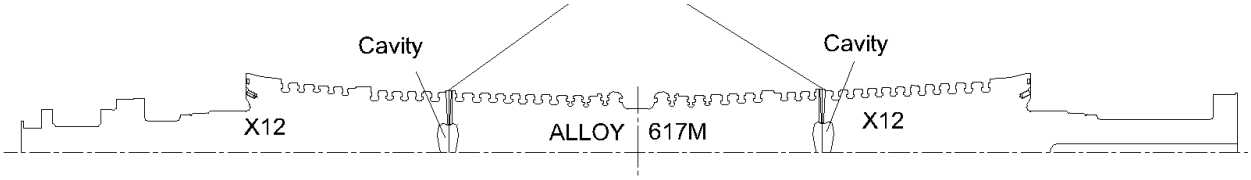

Figure 4: Axisymmetric section of IP rotor

Figure 3 shows cut section view of IP inner casing. It has a dissimilar metal weld construction. There are 2 dissimilar metal weld joints between GX12 and Alloy 625M one on turbine side and other on generator side both inside flow path. *Figure 4* shows axisymmetric cross section of IP rotor. It is a double flow, bi-metallic welded rotor with asymmetrically located extractions. There are 2 dissimilar metal weld joints between X12 and Alloy 617M one on turbine side and other on generator side both inside flow path.

Similar to HP rotor, each of these two weld joints in IP rotor also feature weldment area and cavity. As in HP rotor, in IP rotor too BHEL team has carried out analysis of weld cavity as part of rotor design analysis and design validation/optimization of cavity has been done to the best of their knowledge. In the weld deposit area, the basic configuration of the weldment has been provided by consortium partner having expertise in welding technology. The weldment area has also been included in the rotor design analysis with certain assumptions and stress numbers are generated through FEM. Consultant to decide stress assessment criteria and post processing of stress numbers.

2. **Consultancy Requirements**

Consultancy is required for validating the design of dissimilar metal weld joints (DMWJ) of casings and rotors of HP and IP turbine. For this purpose tentative details are as given below:

2.1 Material data requirement

Consultant has to provide details of material data required for assessment of weldment area in HP and IP turbine rotors and casings. And cavity in case of HP and IP rotors.

2.2 Details of Loads and procedure

Adequacy of analysis, loads during steady state and transient conditions (Startups, trip and planned shutdown) is to be assessed by the consultant. Current analyses of these components are carried out based on available data sheets and curves.

Consultant to inform if some additional load cases/analyses are required and how these will be carried out (by BHEL or by consultant).

3. Scope of consultancy

The scope of consultancy would be

- Review the methodology and assumptions used in FE analysis of weldment area (Weld Joint, Buttering Layer and Heat Affected Zone) in casing and rotor (HP and IP)
- Identify failure modes for dissimilar metal weld joints of casing and rotor (HP and IP) in all modes of operation of steam turbine
- Interpret stress numbers and formulate acceptance criteria for identified failure modes for welds of casing and rotor (HP and IP) as well as rotor cavity
- Validate design of weld joint of casing and rotor (HP and IP) and rotor cavity (HP and IP) for mechanical strength analysis under all operating condition.
- Review BHEL analysis in the rotor weld cavity and perform any further required analysis and provide feedback.
- Any precaution to be taken for safety of weld during operation of turbine.

4. Expected outcome

Consultant will submit a report detailing the design validation of dissimilar metal weld joint which shall include the following

- Comments against each section of the FE analysis report submitted by BHEL along with along with acceptance criteria and rationale behind each comment.
- Comments regarding any missing failure modes and completeness of FE analysis submitted by BHEL
- Comments upon methodology followed by BHEL in the FE analysis of weld joints. Consultant will verify its correctness and suggest the possible improvements
- Comments upon the correctness of assumptions/estimation taken in the course of design analysis.
- Design validation of weld joints from aspect of safety in operation.

5. Methodology of expert review

5.1. BHEL will submit the reports consisting results of FE analysis in weld joints to consultant for design validation. During design validation at their works consultant may need to interact with the team of BHEL through VC/ live meeting.

5.2. In case any information is required by the consultant in addition to details provided in the report submitted by BHEL, consultant may ask the same from BHEL.

5.3. Sharing of final observation of review will be done by relevant consultant at works of BHEL, Haridwar, India against each section of report submitted to BHEL which will require one or more visits.

5.4. In case of utmost requirement consultant may need to visit BHEL, Haridwar during the course of discussions prior to visit against clause 5.3.

The information shared under the project shall be governed by the conditions of a Non-Disclosure Agreement to be signed with the Consultant during Pre Award stage/Post Award stage/Later stage, as applicable. The schedule of work shall be decided as per mutual agreement between the consultant and BHEL. It will depend on the overall project timelines involving other partners who are also responsible for providing interface information to BHEL for finalization of HP and IP turbine weld design and availability of funds.

Taking cognizance of the above stated objectives, it is requested to submit a brief Approach paper mentioning the broad methodology to be followed along with the prospective collaboration with additional resource persons (experts) if needed.

Annexure-B

Expression of Interest Letter

(To be submitted on the letter head of the party submitting the EOI)

To,
Sr. Dy. General Manager
Steam Turbine Engineering (STE-TM)
Bharat Heavy Electricals Limited
HEEP, Ranipur, Haridwar-249403
Uttarakhand, INDIA
Telephone: +91-1334-284237
Email: mbatrani@bhel.in

Subject: EOI for being Consultancy Provider for Review & Vetting of Design of AUSC turbine

With reference to your EOI document Ref. No **BHEL/AUSC/STE/TM/EOI/P2/01** dated _____, we have examined the EOI document and understood its contents and hereby submit our application for pre-qualification for the aforesaid project.

1. We acknowledge that BHEL will be relying on the information provided in the application and the documents accompanying such application for the aforesaid consultancy work, and we certify that all information provided in the application and Annexure-A & C are true and correct; nothing has been omitted which renders such information misleading; and all documents accompanying such application are true copies of their respective originals.
2. We confirm to make available to BHEL, within the stipulated time, any additional information it may find necessary.
3. We agree and undertake to abide by all the terms and conditions of the EOI document.

In witness thereof, I / we submit this application under and in accordance with the terms of the EOI document.

Yours faithfully,
(Signature, name and designation of the Authorized Signatory
Name and seal of the Applicant)

Annexure-C

Mandatory information required for technical evaluation of the institutions/consultancy organizations by BHEL to be furnished along with EOI.

Sr. No.	DESCRIPTION OF REQUIREMENT	Relevant Document Attached (Yes/No)
1	Experience in design of welded rotors and casings of steam turbine components of rating 500MW or above including analysis of weldment area. Experience profile along with academic/industry background of experts in related areas.	
2	List of design of welded rotor and casings for steam turbines performed/vetted for rating 500MW or above of USC parameters (Pressure 270 bar; temperature 600^0C) or above	
3	List of the OEMs of Steam turbine to whom already consultancy services provided along with the brief nature of consultancy work	

Desirable information required for technical evaluation of the institutions/consultancy organizations by BHEL to be furnished along with EOI.

1	Experience in design of welded rotors and casings with dissimilar metal weld joint made of Nickel based alloy which should include design of rotors of any MW rating operating above temperature of 600^0C	

(SIGNATURE)

Disclaimer

The information contained in this Expression of Interest document (the "EOI") or subsequently provided to Applicant(s), whether verbally or in documentary or any other form, by or on behalf of BHEL or any of its employees or advisors, is provided to Applicant(s) on the terms and conditions set out in this EOI and such other terms and conditions subject to which such information is provided.

This EOI is not an agreement and is neither an offer nor invitation by BHEL to the prospective Applicants or any other person. The purpose of this EOI is to provide interested parties with information that may be useful to them in the formulation of their application for qualification pursuant to this EOI.

BHEL also accepts no liability of any nature whether resulting from negligence or otherwise howsoever caused arising from reliance of any Applicant upon the statements contained in this EOI.

The issue of this EOI does not imply that BHEL is bound to select and shortlist Applicants for next stage of the Project.