SECTION-C

TENDER NO. IPR/TN/PUR/TPT/ET/19-20/27 DATED 29/08/2019

Design, fabrication, supply, installation and commissioning of LVDT based set up of thermo mechanical experimental facility to measure pebble bed young's modulus and creep

BRIEF DESCRIPTION:

The machine should have the capability of high temperate thermo-mechanical experiment mainly for Cyclic Compression and Creep of the pebble bed (lithium based ceramic of approximately 0.8 to 1.2 mm pebbles). The test facility should have variable loading rate as mentioned below up to 50 kN. The testing system should have high data capture and sampling rate.

Scope of Work:

The experimental facility is planned to perform cyclic compression and creep experiment on lithium titanate ceramic pebbles of ~ 1 mm in diameter. The strain developed in terms of continuous cyclic loading and strain in terms of time during high temperature were recorded with the help of LVDT (Linear Variable Differential Transformer) sensor for both experiments and used for further calculation of Young's modulus and creep rate. The experiment will be carried out at high temperature and under vacuum environment.

The present experimental facility can be divided in to two parts, one is the main machine which is used for the precise loading for cyclic compression and creep experiment and the second part is an integrated portion with the machine and it consists of (top and bottom piston, sample holder, LVDT sensor for the strain measurement of the sample (pebble bed region), vacuum assembly for the sample region and an external furnace). The schematic of second part (integrated portion with the main machine) is shown in Fig 1 & 2.

a. Detail of the main machine is provided in section 1 of the specification part.
b. Integrated setup for pebble bed experiment schematic is shown in Fig. 1 & 2.
c. For the measurement of precise load and to maintain the accuracy, details are provided in section 2.
d. Sample holder and piston details are provided in section 3.
e. Dimension of the sample holder is mentioned in section 3.5 & 3.6.

f. The experiment is planned to perform at high temperature (800 °C pebble bed region temperature) and the details of furnace is provided in section 4.

g. Both cyclic compression and creep experiments will be performed in vacuum environment as mentioned in section 5, the components should have the ability to withstand at this high temperature as mentioned in section 4.

h. The strain measurement of the pebble bed (ceramic material) has to be recorded using LVDT probe positioned internally as shown in Fig 1 & 2 and the details are given in section 6.

i. The data should be recorded with high accuracy as mentioned in section 7.1 and output format and required output data are mentioned in 7.5 & 7.6.

j. The vendor should study the IPR inputs and submit the design details along with drawings to IPR. The design details should contain positioning of each items in the whole experimental setup like LVDT, thermocouple, sample holder locking with the bottom piston, feedthrough for the thermocouple in the vacuum region, vacuum sealing, dimension of each items, etc.

k. After acceptance of drawings, the vendor may start the fabrication work.

Specification:

1. Machine:

1.	Load cell Capacity	:	50 kN
2.	Application	:	Cyclic Compression and Creep
3.	Test area-height	:	max. approx. 1350 mm ± 50 mm
4.	Test area-width between drive screws of cross head	:	approx. 610 mm ± 50 mm
5.	Rate of loading	:	variable from 200 N/min to 10000 N/min
6.	Test speed range of cross head	:	min. 0.00167 mm/min to max. 100 mm/min
7.	Crosshead speed accuracy	:	± 0.1 % or better of set value
8.	Position control resolution	:	0.1 µm or better
9.	Control parameter	:	Force and/or displacement control
10.	Loading arrangement	:	Servo controlled motorized loading system.
11.	Duration of the experiment	:	100 hrs. (in case of creep); 200 cycle (in case of Young's modulus)

12. Mode of Operations	:	a.) Auto Mode
		b.) Manual Mode
13. Safety	:	a.) Emergency Switch
		b.) Limit switch for up/down
14. Power supply	:	230 volts ± 10 volts

2. Load Cell:

2.1 Load Cell along with indicator – To display the load applied (Preferable make: Syscon, Strainsert, Tecsis LP, ATI industrial automation, etc.).

2.2 Rotational symmetrical design with precise axial alignment should have the option of interchanging with other load cell.

2.3 High accuracy (Linearity, Repeatability, Hysteresis, Resolution) according to ASTM E 4 and ISO 7500-1.

3. Sample holder and Piston:

3.1 Material of construction for both sample holder and piston (upper and lower) should be Inconel 718

3.2 The upper piston should be dynamic for the experiment and lower piston should be in static condition.

3.3 The upper and lower piston fixed/clamped in a way that one can easily replace and assemble with other fixture/piston easily.

3.4 The sample holder is also to be made up of Inconel 718.

3.5 Inner diameter of the sample holder is 45 mm to 50 mm.

3.6 The inner depth of the sample holder is 25 ± 1 mm.

3.7 The sample holder should be easily fixed on the top of lower piston and the clearance should be kept minimum so that it will not move here and there during operation while applying load as well as the condition of expansion and contraction must be focused at elevated temperature.

3.8 Vendor should supply a K-type thermocouple (Accuracy: Class -1, according to the IEC 60 584-2) to measure temperature of pebble bed. The position of the thermocouple at the nearest point of the sample is mentioned in the Fig. 2 which is kept internally through sample holder.

3.9 The maximum possible gap which can be maintained between the inner wall of sample holder and outer wall of upper piston during operation at elevated temperature should not be higher than 0.5 mm.

4. High Temperature Furnace and Controller:

4.1 A cylindrical three zone vertical split tube furnace which can go up to maximum temperature of 1200 °C and continuous operating temperature of 1000 °C. Independent power connection for all three zones to operate them separately.

4.2 Heating zone should be in the range of 95 mm to 105 mm in inner diameter X 360 ± 10 mm in height.

4.3 3 Nos. of K-type thermocouples for furnace controller. Accuracy: Class -1, according to the IEC 60 584-2.

4.4 PID Controller with thyristor drive which can program at-least 10 segment with variable ramp and dwell time.

4.5 Heating rate of the furnace should be in the range of 1 to 10 °C/min.

4.6 The expected accuracy is ± 5 °C or better.

4.7 Proper insulation should be maintained to keep the outer temperature of the furnace below 60 °C and should not affect the frames of the machine.

4.8 The furnace should be positioned vertically at the center of the specimen during test and should have the option of moving (up and down) without changing anything in the main machine.

4.9 Digital display of temperatures.

5. Vacuum Chamber:

5.1 The test area should be covered by vacuum environment as shown in the schematic drawing.

5.2 The vacuum should be attained by a direct driven two stage rotary vane vacuum pump. The vendor should give the make, model and other details of the rotary vacuum pump.

5.3 The ultimate vacuum level of the quoted vacuum pump should be at least $1x10^{-2}$ mbar.

5.4 Vacuum chamber material should be made of transparent quartz.

5.5 The stability of quartz at higher temperature should be above 1000 °C.

5.6 The wall thickness of the quartz should be selected in a way sample should get temperature of 800 °C and during vacuum it should not get broken as well.

5.7 The outer diameter of the quartz should be selected by keeping in view of inner diameter of furnace is between 95 mm to 105 mm so that it could be around 80 to 90 (OD).

5.8 Vendor should provide a suitable water chiller in this offer for cooling the vacuum flanges at both the ends of the vacuum chamber. The cold water will be circulated through the vacuum flanges to protect the O-rings due to heating of furnace.

6. LVDT (to measure strain):

6.1 01 Nos. of LVDT (preferable make - Messotron, Trans-Tek, Singer Instruments and Control, TE connectivity or better)

6.2 0 - 5 mm or ± 2.5 mm range with resolution of 1 micron.

6.3 Accuracy: 0.1 % or better of full scale output

6.4 Sensitivity of LVDT sensor: approximately 48 mV/V/mm or better

6.5 A LVDT should be placed inside the vacuum chamber to access the strain developed in the sample (pebbles) within the sample holder (please see the location in the schematic fig. 1 & 2).

6.6 Position of the strain measurement probe can be discussed during the drawing submission by vendor to IPR.

6.7 During experiments any kind of inaccuracy or error produced in the measurement of LVDT due to high temperature and thermal expansion of piston should be taken care by the vendor.

7. Data Acquisition and Output:

7.1 Data logging rate: 100 Hz or better.

7.2 Software shall provide provision to extract logged data in the following steps: 1 Hz, 10 Hz and 100 Hz.

7.3 The software should have the facility of different method of testing for cyclic compression and creep experiment.

7.4 The software should have user programmable loading pattern.

7.5 The software should have GUI to provide user commands and to monitor the real time data.

7.6 The data output file shall be MS excel compatible (.csv format).

7.7 The required output is test time, travel sensor (LVDT sensor), standard travel (crosshead movement), standard force, temperature, vacuum, sample strain and stress.

7.8 Resolution: 16-bit or better

8. Water chiller

Vendor should provide a suitable water chiller to circulate the cold water through vacuum fittings to protect O-rings due to heating of furnace in this offer. Water temperature should be adjusted through digital display control panel. Vendor should also provide the chiller technical details such as cooling capacity, water flow rate, dimensions, water tank capacity, outlet water temperature, power supply, end connections, etc.

9. Vendor should fill the data sheet along with the offer

- Vendor should quote separately for the following spare items as an optional items:

Sr. No.	Item	Quantity
1.	Compatible 100 N load cell. Accuracy according to ASTM E 4 and ISO 7500-1.	2 Nos.
2.	LVDT as per point 6	2 Nos.
3.	Transparent quarts tube as per point 5.4 - 5.6	3 Nos.
4.	O-rings as per point 5.7	2 sets (Used in the system)
5.	Please mention other spares / consumables and their cost	
6.		
7.		

10. Warranty:

Vendor should provide minimum warranty of one year for any manufacturing defects after the date of acceptance at IPR.

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11. Scope of supply:

Complete unit (Main machine, rotary vacuum pump, furnace, LVDT sensor, data acquisition system, water chiller)

12. Schedule:

1. Vendor should submit the drawings of machine as per Sr. No. 12 and details of machine as per Sr. No. 13 within 15 days from the PO.
2. IPR will give the comments/approval within 7 working days after receiving the drawing and details (as described in Sr. No. 12 and Sr. No. 13) from the vendor. But the ultimate performance of the machine will be on the vendor side. To satisfy the ultimate required performance, vendor can contact to IPR to take permission for any modifications or change in the design and drawing of machine.
3. After the approval from IPR, vendor can start the fabrication.
4. Vendor should inform IPR for the FAT/PDI at the vendor/factory site well in advance preferably 15 days before. Vendor need to submit the documents/test reports for satisfying PDI /FAT requirements as mentioned in Sr. No. 14 for the approval before dispatch of machine.
5. The delivery of the machine should be within 3 months from the date of approval of drawing. Vendor should complete the installation and commissioning at IPR within one month.
6. Proper packing should be done for the shifting of instrument from vendor/factory site to IPR.

13. Drawings of machine:

1. Dimension details of the machine with each individual items
2. Dimension details of the piston and sample holder
3. Positioning of each item in the machine including the controllers
4. LVDT sensor position
5. Thermocouple placement
6. Sample holder locking with the bottom piston
7. Vacuum sealing details

14. Details of machine:

1. Utility requirements like power supply, water, total space, etc.
2. Details of furnace
3. Details of heating element, thermocouples and their location
4. Information of material used for construction of machine
5. Details of water chiller and water inlet and outlet connection details

15. Factory Acceptance Test/Pre dispatch inspection (FAT/PDI):

1. Temperature, vacuum level, cross head speed, load cell, LVDT and data acquisition system will be tested at Vendor's place.
2. At least 1 hour of holding at 1000 °C of furnace will be done to check the temperature accuracy and heating rate as well during this experiment.
3. Cyclic Compression and Creep experiment will be done with Li_2TiO_3 pebbles (IPR will provide Li_2TiO_3 pebbles for the experiment)
4. Stability of the machine for 50 kN load and stress analysis report
5. Calibration Certificates:
   a) LVDT along with signal conditioner
   b) Load cell along with signal conditioner
   c) Thermocouples
   d) Cross-head movement of the machine
6. After FAT/PDI, the inspection report will be reviewed by IPR expert committee for its approval. After completing the approval procedure IPR purchase section will issue the dispatch clearance to the vendor.

16. Acceptance Test at IPR:

1. The machine along with its all components/parts should be installed and commissioned at IPR by the vendor.
2. Vendor should provide proper training of the machine to IPR personnel for its operation.
3. The following experiments will be carried out at IPR:
   a) Temperature, vacuum level, cross head speed, load cell, LVDT and data acquisition system will be tested after installation.

b) Cyclic Compression and Creep experiments will be carried out with Li_2TiO_3 pebbles.

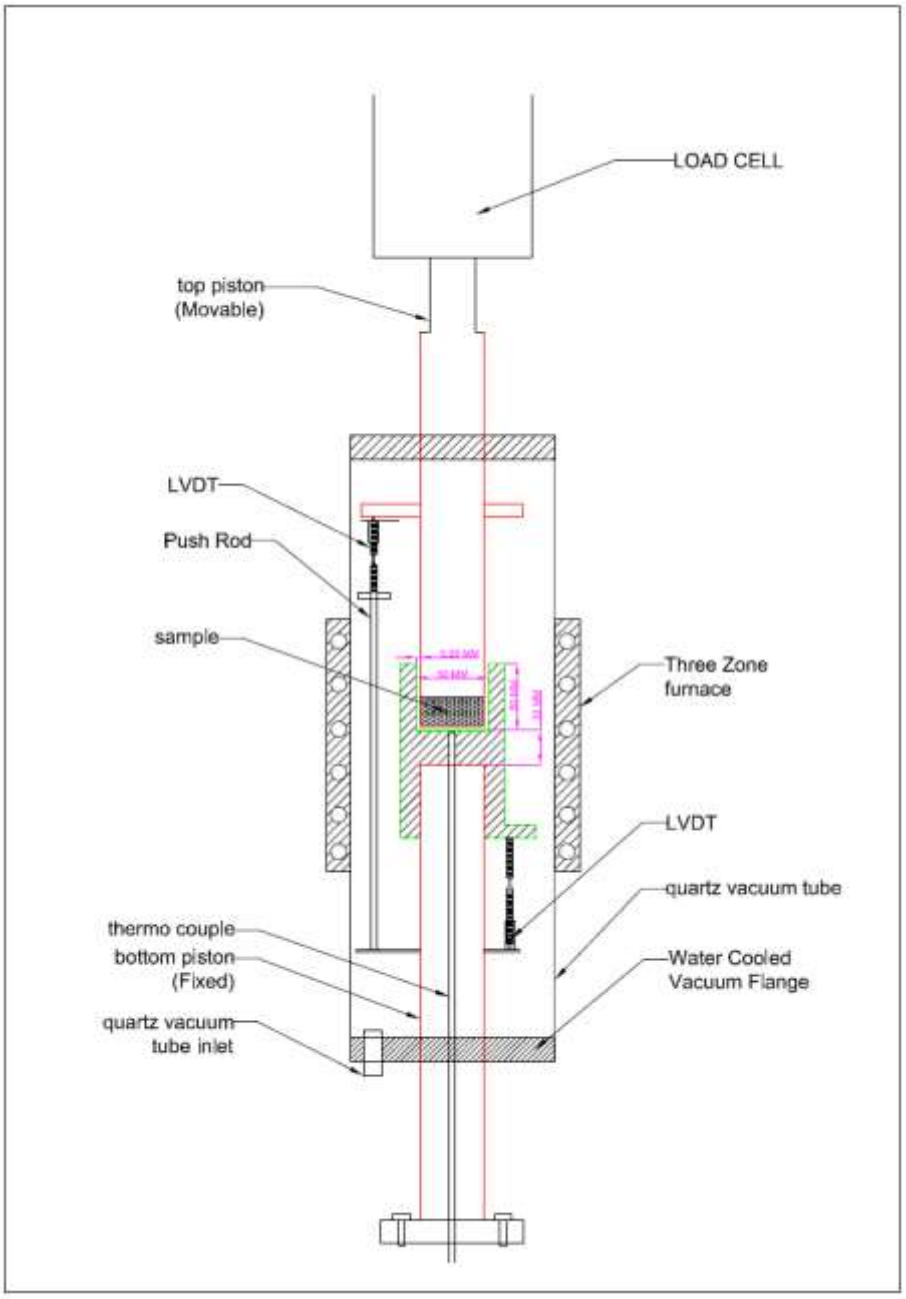

Fig. 1. Schematic of the Experimental set-up

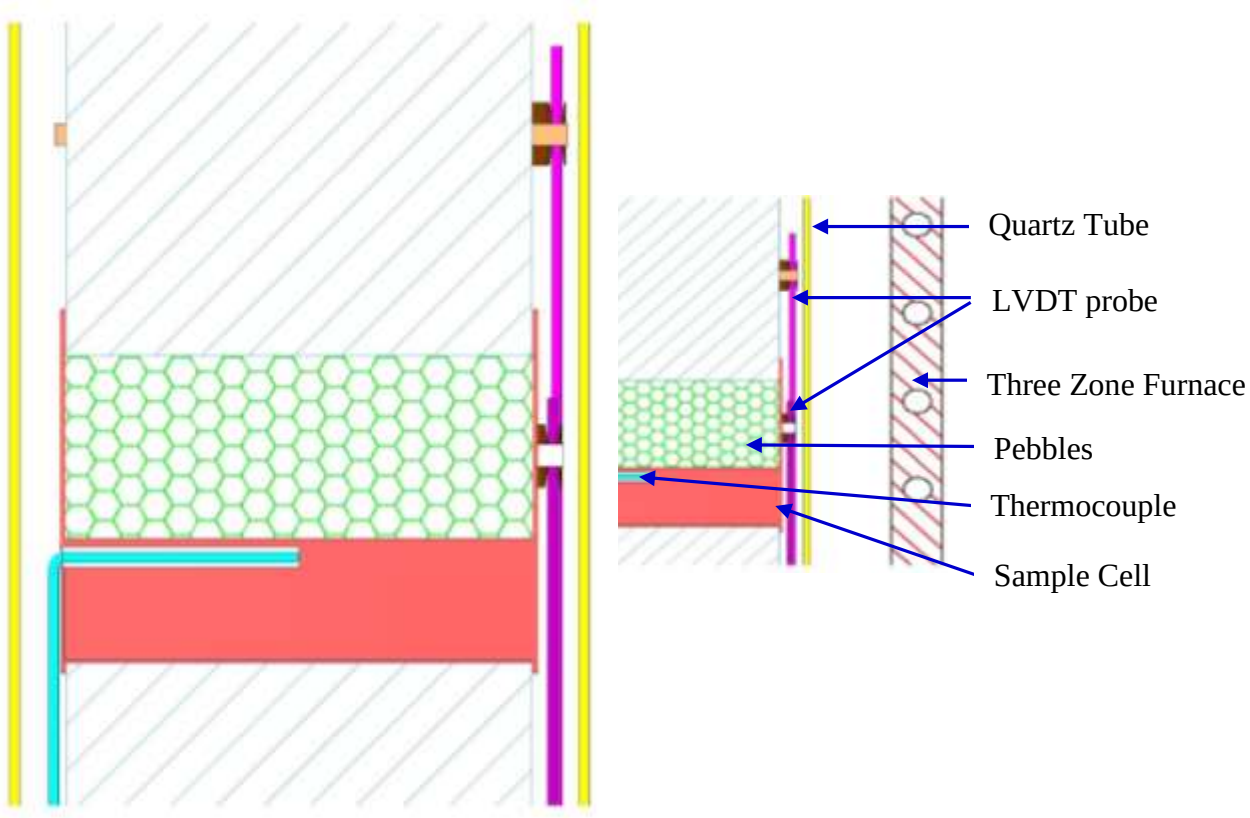

Fig. 2. Schematic of Alternate locations of LVDT