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ENCIO PROJECT: AN EUROPEAN APPROACH TO 700°C POWER PLANT.

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Abstract

ENCIO (European Network for Component Integration and Optimization) is an European project aiming at qualifying materials, components, manufacturing processes, as well as erection and repair concepts, as follow-up of COMTES700 activities and by means of erecting and operating a new Test Facility.
The 700°C technology is a key factor for the increasing efficiency of coal fired power plants, improving environmental and economic sustainability of coal fired power plants and achieving successful deployment of carbon capture and storage technologies.
The ENCIO-project is financed by industrial and public funds. The project receives funding from the European Community's Research Fund for Coal and Steel (RFCS) under grant agreement n° RFCPCT-2011-00003. The ENCIO started on 1 July 2011. The overall project duration is six years (72 months), to allow enough operating hours, as well as related data collection, investigations and evaluation of results.
The ENCIO Test Facility will be installed in the "Andrea Palladio" Power Station which is owned and operated by ENEL, located in Fusina, very close to Venice (Italy). The Unit 4 was selected for the installation of the Test Facility and the loops are planned for 20.000 hours of operation at 700°C.
The present paper summarizes the current status of the overall process design of the thick-walled components, the test loops and the scheduled operating conditions, the characterizations program for the base materials and the welded joints, like creep and microstructural analysis also after service exposure.

Key words: Advanced Ultra Supercritical power plants, Nickel superalloys, welded joints, test loop, creep behaviour, microstructural stability.

1. Introduction

In the ENCIO-project scientific and technological efforts aim to the successful deployment of 700°C technology in coal fired power plants. The key elements of ENCIO are the installation and operation of a test facility in Fusina, at an ENEL power plant in Italy. The project focus is on practical investigations, aiming at proving manufacturing, welding, repair and life-time concepts for thick-walled components.
Europe is still in the global lead for the 700°C technology in the field of fossil-fuel based power generation. In order to continue with this successful technology development ENCIO is the next important step to deploy this technology and to remain competitive. Therefore a group – representing the leading European power generators and equipment suppliers – has increased its efforts to speed up the evaluation and assessment process out of COMTES700.
The 700°C technology is a key factor:

- Increasing efficiency of coal fired power plants,
- Improving environmental and economic sustainability of coal fired power plants,
- Achieving successful deployment of carbon capture and storage technologies.

The strategic importance of these R&D activities is evident for the electricity sector. The integration of the renewables (RES) is one of the top priorities of European policy. The consequence for the electricity supply system is that an appropriate balance between intermitting and dispatchable generation is absolutely necessary. The fossil fuel based power generation provides the back-up power and grid control function which are necessary to ensure that the targeted contribution of renewable resources to the electricity generation portfolio can be achieved.

It is expected that the price of electricity will increase further as soon as the RES share, the demand for reliable back-up power as well as the global demand for coal will increase. Different investigations in forecasting the evolution of the electricity sector - in Europe and worldwide - show that beyond 2025 the commercial viability will be given which would fit into the time line of the technical maturity of both 700°C technology and carbon capture & storage technologies.
The ENCIO project meets the goal of the RFCS program for coal in terms of efficiency enhancements and in terms of carbon capture. The scientific and technical approach of ENCIO consists of the connection in use of new and essentially improved Ni-based alloys, the development and selection of new manufacturing processes and consequently to test (under realistic operation condition) new design features of components needed for the boiler as well as for the turbine.
ENCIO is the perfect transition from pilot towards demonstration, because it contains elements of both with the goal to have a ´mature´ technology available at the end of the project. In ENCIO the whole European expertise and competence – generators and suppliers – are concentrated. This is a clear signal that the proposed work can be done in a proper manner ensuring that the project objectives can be fully achieved.

Out of the structure and content of the work it is secured that the outcome of ENCIO will deliver significant progress for the 700°C technology, a progress which will be unique in a global view.
The innovative part can be derived from the fact that new material concepts, new manufacturing issues and new design features for the components will be demonstrated, an absolute condition for the successful – environmental, technical and sustainable – deployment of the 700°C technology and the basis for an efficient carbon capture process and for saving our coal resources.
The key elements of ENCIO are consequently the use of new and essentially improved Ni-based alloys, the development and selection of new manufacturing processes and to test under realistic operation condition new design features of components needed for the boiler as well as for the turbine. The manufacturing is the key hurdle for a technically feasible and commercially viable deployment of the 700°C technology and consists of more precise specifications for the ingot, forging, casting, welding including heat treatment etc. These new process steps will be tested by a smart selection of component elements required for a successful future operation.
The consequence of the significant progress beyond state of the art is a significant improvement for the coming generation of fossil fired power plants by the application and demonstration of their maturity of a complete new type of materials.
The industrial benefit is twofold and can be described as follows: for the European industry active in the electricity sector the 700°C technology provides an urgently

needed technology and a clear opportunity for world-wide application of this technology as a technology leader.
The strategic relevance is given – as pointed out before – through its role as technology provider in order to meet the European Councils decisions in mastering the climate change and to sell this technology worldwide. The competitiveness of both – electricity sector and equipment supplier – will be improved. Concerning the generators the improvement is given by the strategic contribution to a balanced portfolio in lowering the cost increase due combatting climate change.
For the equipment suppliers their market position will be strengthened in a global sense. The credibility of the envisaged goals can be derived by the consistency of the working packages and their deliverables as well as by the integrated responsible experts. The ENCIO project is targeted for field testing but includes also modelling combined with simulation. The industrial participation will cover at minimum level about 60% of all efforts and is relevant in terms of numbers and competence.

The thematic area is an European one: it helps to make the European Council decisions for decarbonizing the electricity sector reality. The direct link between highly efficient thermodynamic processes and carbon capture technology is the key for a successful deployment. The activities of the European Union (EU) in the field of CCS justify this in addition. The clear need for a European approach is the fact that the partners constitute themselves European wide and fulfill the specific request for high level skills and expertise. The successful demonstration of all features of the 700°C technology will be applied all over Europe and globally as a follow-up.
As described previously the strategic importance is evident for the electricity sector. Only by the back-up and grid control function of the dispatchable generation as nuclear and fossil the strongly intended major contribution of renewable resources to the electricity generation portfolio can be achieved. A reduction of the emissions in terms of CO2, SOx, NOx and dust as well as the saving of resources by less coal consumption will deliver an essential improvement to the health and safety.
The ENCIO project will contribute to the preservation of natural sources and environment. This is possible by more efficient processing technologies, reducing materials and energy consumption.
At the end it will support the use of renewable resources in the electricity sector.

2. PROJECT OBJECTIVES

The key goal of ENCIO is to concentrate all scientific and technological efforts in order to make the 700°C technology ready for deployment. ENCIO is an important step before the erection of a 700°C power plant can start. The ENCIO project consists of the installation of a Test Facility in the ENEL coal fired power station "Andrea Palladio", based in Fusina (north-east Italy). The rationale behind is that the 700°C technology is the pre-requisite for a successful deployment of the significant technology paths for carbon capture (i.e. post-combustion and oxyfuel requesting). Both technology lines - high efficiency and carbon capture - will converge in a commercially viable power plant:

700°C technology combined with carbon capture technology, i.e.
< 100g CO2/kWh and η > 40% net efficiency by 2020

The experimental, demonstrational and investigational activities of ENCIO pursue the following targets:

- Provide proof of design and material behaviour of thick-walled components under real operating conditions,
- Close main technical open items derived out of the comprehensive analysis of COMTES700, [1]
- Test new developed materials and manufacturing options (e.g. post weld heat treatments) to improve the reliability of weldments made out of Ni-based alloys,
- Develop a life-time monitoring concept for pipes made out of Ni-based alloys,
- Explore materials and manufacturing options having the potential to reduce the investment cost of 700°C technology and improve the load change behavior,
- Verify the technical conditions for achieving high efficiency and better environmental figures (lower emissions).
- The ENCIO Test Facility (TF) will be installed in the "Andrea Palladio" Power Station which is owned and operated by ENEL, located in Fusina (Italy). The Unit 4 was selected for the installation of the Test Facility [2-4]. This unit has the following characteristics:
    - Boiler type: two pass boiler
    - Burner configuration: tangential
    - Steam capacity: 1050 t/h
    - Production capacity: 320 MWe
    - Fuel: hard coal + RDF (Refuse Derived Fuel)
    - Superheater steam temperature: 540°C
    - Superheater steam pressure: 177 bar

Figure 1: ***Enel's power station "Andrea Palladio" Fusina (Venice Laguna) (Courtesy of ENEL)***

The Fusina power plant is perfectly qualified for installing the TF, as it has previous experiences in the frame of innovation projects and it was already involved as host power plant in other EU-funded projects, such as DEBCO (Demonstration of large scale Biomass Co-firing) and H2-IGCC (Low emission gas turbine for hydrogen rich syngas). Andrea Palladio station also already hosts a hydrogen fuelled demonstration plant, including a demonstrative 16 MW GTCC (Gas Turbine Combined Cycle), where hot component materials (combustor and gas turbine) are tested under long term operation with hydrogen rich gas mixtures. All DCS (Distributed Control System) data of such a facility are remotely monitored in real time by ENEL IIN offices based in Pisa. The control, maintenance and operation of the hydrogen fuelled power plant are performed with the support of personnel of the power station.

3. Structure, timeline, organization and funding

The ENCIO-project is financed by industrial and public funds. The project receives funding from the European Community's Research Fund for Coal and Steel (RFCS) under grant agreement n° RFCPCT-2011-00003. The ENCIO project started on 1 July 2011. The overall project duration is 6 years (72 months), to allow enough operating hours, as well as related data collection, investigations and evaluation of results.

The industrial fund consists of contributions of generating companies and of equipment and materials suppliers. Five partners are contractors to RFCS:

- VGB (VGB PowerTech e.V.) as co-ordinator
- CSM (Centro Sviluppo Materiali S.p.A.)
- ENEL IIN (ENEL Ingegneria e Innovazione S.p.A)
- ENEL GEM (ENEL Produzione S.p.A)
- HPE (Hitachi Power Europe GmbH)

VGB will be responsible for the overall project co-ordination and management including the relations towards the EC RFCS. VGB is also the coordinator of the COMTES700+ program, that is the overall umbrella also for the other project running in Germany: the GKM HWT II hosted in Mannheim GKM power plant [5,6]. The structures and the main targets are summarized in figure 2.

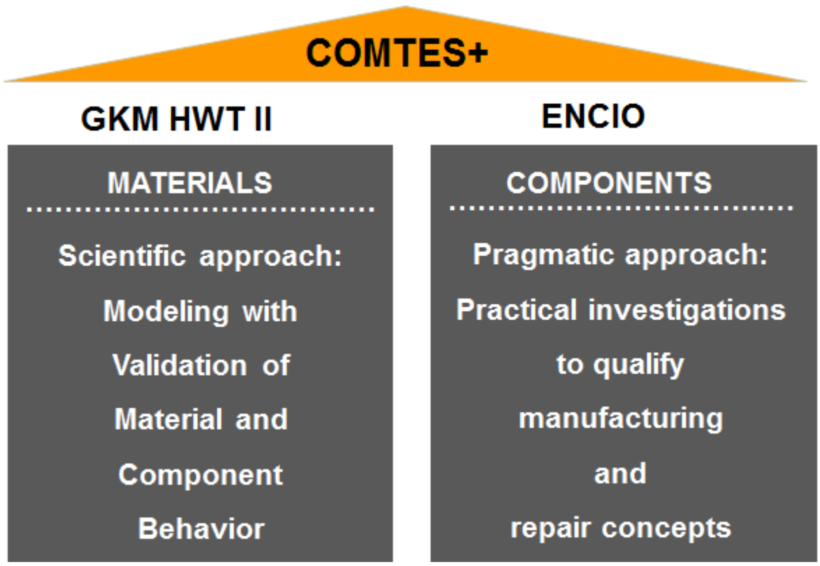

Figure 2: COMTES700+ umbrella with GKM HWT II and ENCIO targets

The generating companies behind this proposal are CEZ a.s. (Czech Republic), EDF/Electricité de France, EnBW Kraftwerke AG (Germany), ENEL (Italy), E.ON New Building & Technology GmbH (Germany), STEAG GmbH (Germany), EVN AG (Austria), GDF Suez (France), GKM/Grosskraftwerk Mannheim AG (Germany), RWE Power AG

(Germany), Vattenfall Europe Generation AG (Germany) and Vattenfall A/S (Sweden) as well as Eskom Generation Business Engineering (South Africa). Those companies represent a large share of the generated electricity in Europe. ESKOM is an important international partner in clean coal technologies and in abating climate change via CDM (Clean Development Mechanism) and other instruments.

Their high overall contributions to the project emphasize their strong interest and their commitment to clean coal technologies with very high efficiencies. On the other side the generators regard the funding from RFCS as very important as it renews the European Union's interest in supporting 700°C technology and underlines the continuity of European energy research.
Manufacturers and suppliers are also involved in ENCIO - either as a contractor (HPE) or as an associated partner (HORA/Holter Regelarmaturen GmbH &Co. KG, Sandvik AB, Sempell AG, Outokumpu (formerly ThyssenKrupp VDM GmbH), V&M/Vallourec & Mannesmann Tubes, Voestalpine Giessen Traisen GmbH). Nippon Steel Sumitomo Metals Co. (formerly Sumitomo Metals) is also an associated partner supplying HR6W pipes and the testing has been allocated at CSM under separate contract.
Associated partners have agreed to contribute to the project in relation to the added value of their order volume. They will have access to the know-how related to the provided materials and components. This partnership approach will ensure a close co-operation, share of expertise and commitment of all parties involved.

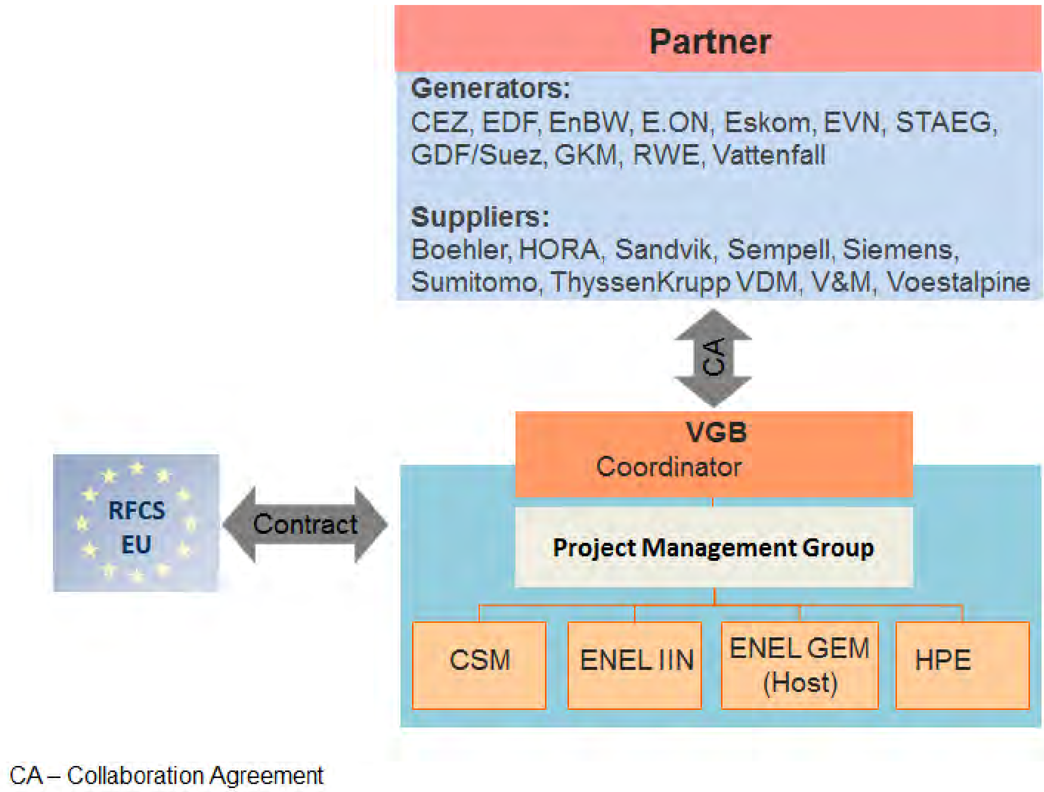

Figure 3: ENCIO project structure

4. Project Schedule

The main time milestones are:

- late February 2014 – start of erection activities outside the boiler
- Summer 2014 – Fusina's outage for erection activities inside the furnace (i.e. additional
- superheater (SH) bundles, etc.)
- early Fall 2014 – start of experimental activity

Fall 2017 – stop of experimental activity and start of investigation activities after dismantling

The project structure of the ENCIO project is shown in the chart.

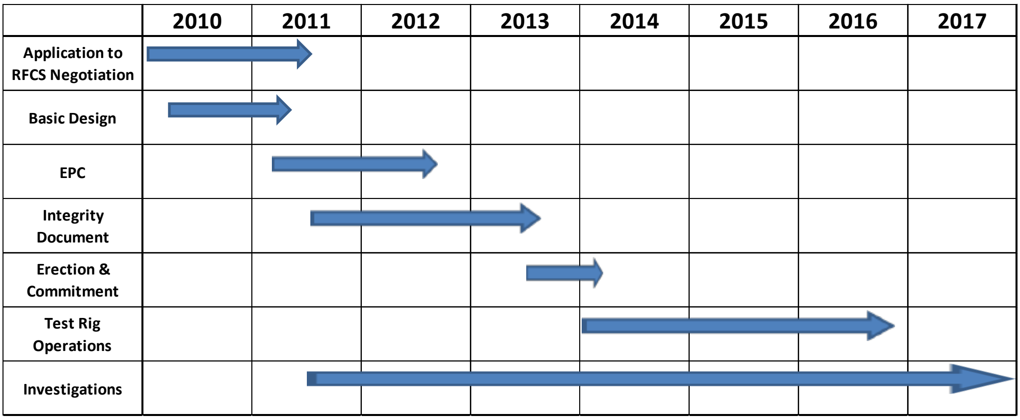

Figure 4: Project structure

5. Description of the tests loops

The Test loop description is shown in figure 5 as well as the 3D schematic view:

- Steam is taken from existing boiler (Host Plant) at 540°C
- Steam is additionally superheated up to 705°C by additional SH bundles installed into the furnace
- Additionally superheated steam is sent to experimental components
- Experimental components are installed in four Test Loops having the following scopes:
    - Test Loop 1: Development of pipe repair concept
    - Test Loop 2: Test of Hot Isostatic Pressing (HIP) parts and weldments as well as life-time monitoring
    - Test Loop 3: Test of different Ni-based alloys and elements
    - Test Loop 4: Test of turbine cast material and weldments

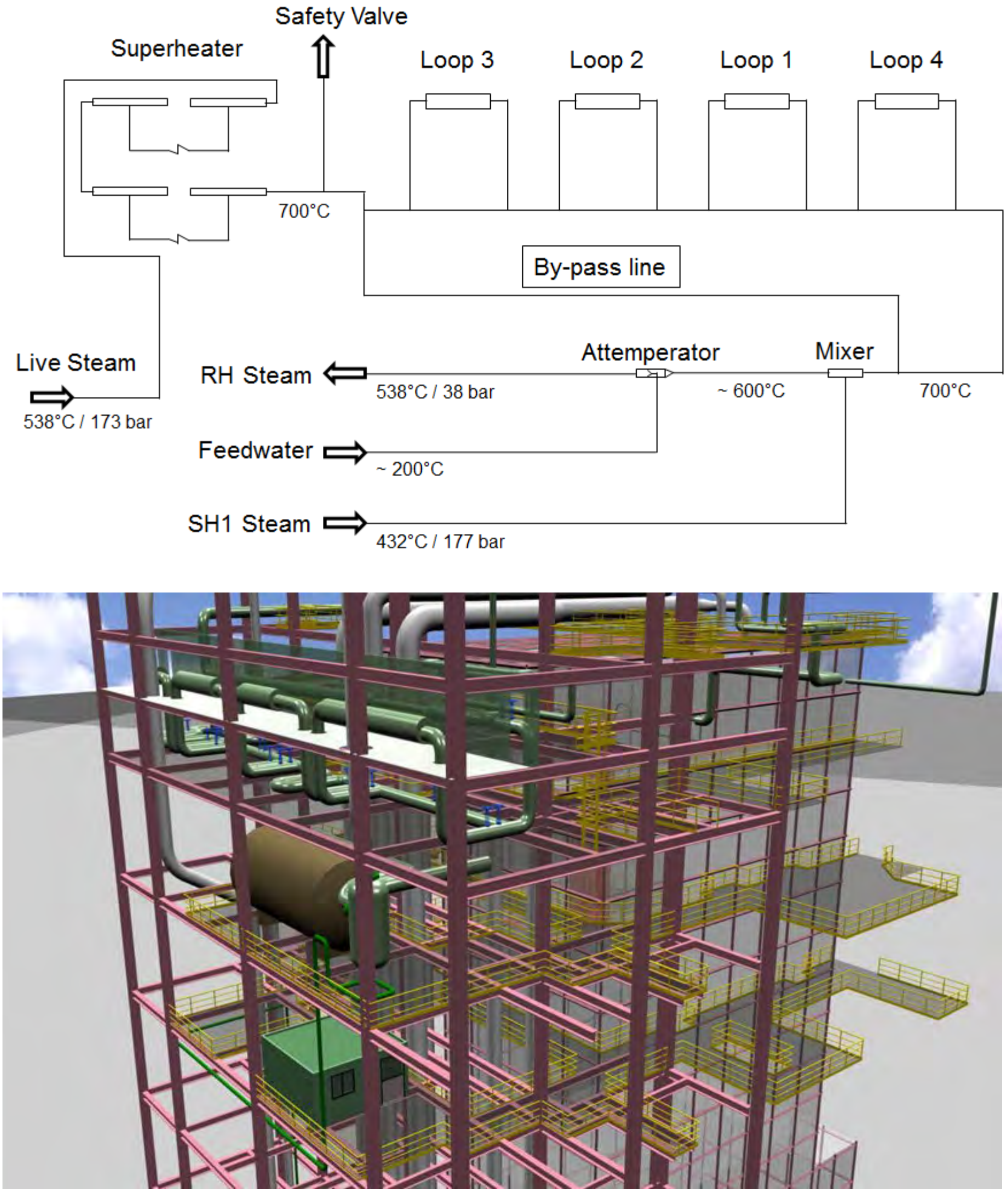

Figure 5: P&I Diagramm and 3D-View of the Test Facility

5.1 TEST LOOP 1: Development of pipe repair concept

Take advantage of additional investigations carried out in COMTES700 and in ENCIO to get optimized WPS. Prior to start any weld testing basic investigations have been done to characterize the aged material.
Complimentary to COMTES700 different heat treatments (pre-/post-) will be applied and a trial weld of each material combination and/or welding method will be tested destructively. Trial welds will be carried out and all those welding methods without any

crack indication will then be selected to produce components to be installed in the test loop.
Different NDT (Non Destructive Test) methods will be applied and tested to assure high quality standards.
Non Destructive Surface Tests will be performed frequently during operation for all test welds. A final repair with orbital TIG (Tungsten Inert Gas) narrow gap and electrode welding will be executed on additionally aged pieces of A617B (having been in operation in COMTES700).

5.2 TEST LOOP 2: Hot Isostatic Pressing (HIP) parts + Lifetime monitoring

The HIP technology is interesting for fabrication of T-pieces, valve bodies and turbine parts. Although this technology is already commercially applied in other fields, it has not yet been adopted for boiler and turbine pressure parts in power plants (alloy 617B or alloy 625). The HIP-technology is promising for substituting expensive castings and consequently a cost reduction may arise from its application to 700°C technologies.
NDTs will be performed frequently during operation for all test welds. After the end of operation final repair welds will be executed on all dismantled pipes of Test Loop 2.
The creep behaviour of alloy 617B is monitored by running tests under respective load and temperature, as well as by using a thin wall piece designed for ~30000 h (measuring and monitoring of the creep online).

5.3 TEST LOOP 3: A617 OCC / A263 / HR6W / A625 cast base material and dissimilar welded joints

The optimized chemical composition of A617B, called A617OCC is applied to explore possible improvements in weldability, which is due to less formation of chromium carbides. Additionally, an optimized melting process is implemented to reduce the amount of impurities in the ingot. Such an optimization has the potential to make welds more reliable. This is also expected to be an option to reduce relaxation-cracking and hot-cracking occurrences, which is one of the objectives of ENCIO's tests and investigations. It can be expected that due to the new melting process the improved weldability may lead to reduced pre- and post-weld heat treatment requirements. Thus, A617B OCC has also to be considered as a possible option for reduction of investment costs of 700°C technology.
Furthermore, other Ni-based alloys like A263, HR6W and A625 will be tested. A263 shows a high potential in cost reduction but has not yet been in test operation.
It is also planned to test other material like HR6W for the temperature range 620°C to 700°C from suppliers such as Sumitomo. These materials will be installed additionally to the ENCIO test program.
The weldments of the material combinations A617B OCC – HR6W and A263 - A625 cast are tested and compared with each other. This is necessary as the combinations A263 - A625 cast (neither with nor without heat treatment) and A617B OCC – HR6W have not yet been tested and investigated with the required heat treatment.
This aims at an optimized design for the overall plant with regards to competiveness, costs and performance.
NDTs will be performed frequently during operation for test welds. After the end of operation final repair welds will be executed on dismantled pipes of Test Loop 3 which are long enough for this purpose, followed by microstructural investigations, mechanical and creep testing.

5.4 TEST LOOP 4: Turbine cast material

Need to prove thick walled welds in the range of the real pipe dimensions of a demonstration plant with material combination alloy 617 OCC - alloy 625 cast. The material combinations alloy 617 OCC/alloy 625 is not tested in COMTES700 (real dimensions).
Even if there was no negative indication about the behaviour of the welded material in the combination alloy A617B forged - A625 cast material, the dimensions of the test weld in COMTES700 had been at relatively thin wall thickness (80 mm). So there is the need to prove thick-walled welds in the range of the real cast dimensions of a demonstration plant with material combinations A617B OCC - A625 cast. The weldments A625 cast - A625 cast with wall thickness in the range of 150 mm was not foreseen in earlier designs for this component but with the post-weld heat treatment needed for A617B OCC - A625 cast this design issue is necessary to be introduced and tested.

6. Erection concept

Welding technologies that are suitable for on-site applications (i.e. orbital TIG narrow gap welding and electrode welding), are applied both for new material and aged material, because it will be mandatory needed to develop a repair concept for the future construction of commercial size power stations based on 700°C technology. Since these welding technologies make it possible to perform welding activity not only in the workshop, ENCIO will provide the proof of feasibility of such a welding approach.
Different non-destructive methods will be applied to secure the safety of the TF. Among others, PTs (**P**enetration **T**ests) will be applied to check the surface of weld seams for flaws.
UTs (**U**ltrasonic **T**ests) are decisive to identify flaws in the weld seam.

The overall assembly details of the 4 test loops are summarized in figure 6.

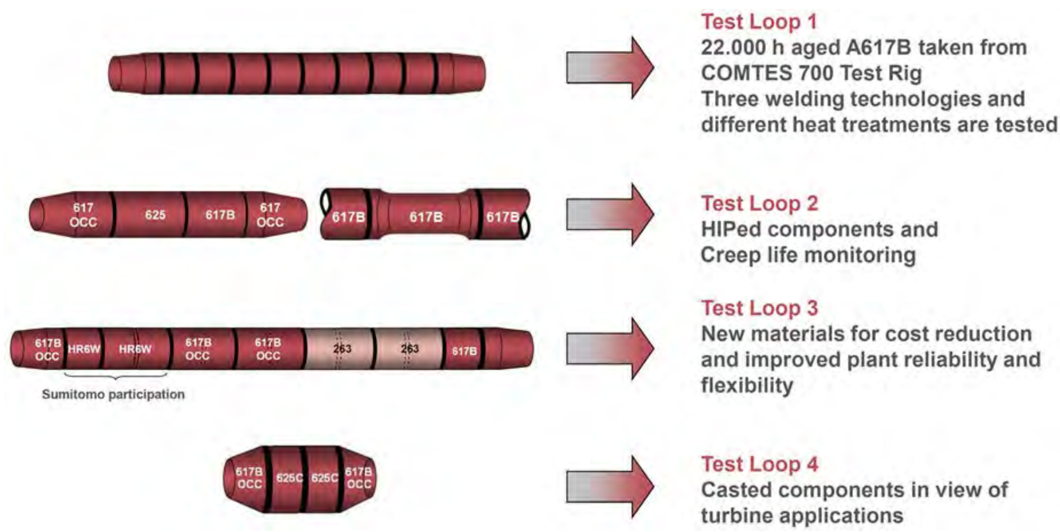

Figure 6: details of the test loops

7. Project work plan

The ENCIO project is structured in six WPs (**W**ork **P**ackages) with clearly defined responsibilities and deliverables, meeting the envisaged objectives.

WP1 Engineering (Work Package leader: Hitachi Power Europe GmbH, **HPE**)
This WP covers all activities necessary to design the TF and to integrate the equipment into the host plant. It also includes the selection and design of components, such as superheaters, steam pipes, valves and test loops, as well as of the C&I (Control & Instrumentation) system and the according measuring devices and the permitting process.

WP 2 Materials and Manufacturing (Work Package leader: **HPE**)
This WP includes all procurement of materials and components, as well as manufacturing of trials to prove weldability and mechanical properties prior to installation. Components to be installed will then be properly manufactured. NDT methods will also be applied. It also includes the qualification through inspection bodies.

WP 3 Erection and Commissioning (Work Package leader: ENEL Ingegneria e Innovazione S.p.A., **ENEL IIN**)
This WP includes all activities needed to install the TF in the host plant, the related cold and hot commissioning, as well as the dismantling of the TF after completion of the demonstration program.

WP 4 Investigation (Work Package leader: Centro Sviluppo Materiali S.p.A., **CSM**)
This WP includes all investigations necessary to qualify components and to characterize material properties. This comprises the assessment of base material (before and after operation), welded joints (before and after operation) and repair welds (after dismantling).
It also includes a creep test program, which is essential especially for materials (e.g. A617B aged, A617B OCC, A263) and manufacturing processes (e.g. forging, extrusion, casting, HIP), where knowledge of material behaviour is very poor. Evaluation of results is another important item addressed in the WP in order to provide a basis for the design, operation and repair methods for future 700°C power plants.

WP 5 Operation (Work Package leader: ENEL Produzione S.p.A., **ENEL GEM**)
This WP includes the start-up, operation and monitoring of relevant TF data. Operating data will be properly stored on a server and periodic inspections and non-destructive testing will be carried out.

WP 6 Co-ordination and dissemination (Work Package leader: VGB PowerTech e.V., **VGB**)
This WP includes the project management and reporting to assure meeting the project objectives, the budget, time line and compliance to RFCS rules. Furthermore, the management of the collaboration between the project partners and the protection of IPR (**I**ntellectual **P**roperty **R**ight) will be part of the Work Package. Dissemination actions (e.g. events, publications) are an essential part of the scope of this WP.
The inter-dependencies between the different WPs are consisting of well-defined interfaces as input and output features - a pre-requisite for an efficient and successful performance.

Due to the ENCIO project objectives comprising the implementation of new materials, new manufacturing processes and new welding and testing features a comprehensive material qualification procedure is required to comply with obligations of the certified bodies. As this certification process follows defined rules the preparatory work before erection cannot be expedited. Nevertheless the feasibility to start qualification tests prior to the RFCS commencement date has to be explored.

8. Main facts

TF installed - tie-ins installed end of Aug. 2012 (figure 7) [4]

- all time critical orders already put in place
- test loop 1: material available, trial welds started
- test loop 2: per-investigation trials accomplished and pipe manufacturing completed
- test loop 3: pipe produced (figure 8) and weld manufacturing started. NDE started. Pipe cut and sampling started (PMA, WPQR, R&D purposes)
- test loop 4: material manufacturing completed
- Investigations on all the base materials are started
- Investigations on HR6W welded are started

End of erection scheduled end of August 2014
Commissioning planned to start on September 2014
Experimental operation to be started by end 2014

Figure 7: tie-in installation [2]

Figure 8: HR6W pipe – experimental component (courtesy of NSSM co.) [2]

9. Work package Investigation

This work package is leaded by Centro Sviluppo Materiali S.p.A. (CSM) with the cooperation of Technische Universität Darmstadt (TUD) and VGB PowerTech e.V. (VGB).

The WP4 main objectives are:

- The definition of the ranking of manufacturing processes and repair concepts to reduce the risks in future long-term plant operations,
- The identification of life time determinants in particular including main damage mechanisms in long-term service exposed components (through a comprehensive characterisation of materials and components), in order to provide a basis for design, operations and repair methods on future 700°C power plants.

The materials scheduled to be installed in the five test loop are: A617B, A617B OCC, A625, A263, HR6W. The production processes scheduled for component production are: forging, casting, extrusion, pilgrim and HIP.
The welding procedures scheduled for the components production are: Orbital TIG narrow gap welding (cold wire), Electrode welding and TIG narrow gap welding (hot wire).
This WP will also support WP2, by carrying out laboratory analyses on trial welded joints devoted to destructive testing (DT) for achieving the proof of weldability and fabricability. Depending on the case, welded joints will be tested with or without pre weld heat treatment. Post weld heat treatment will always be applied.

Task 4.1 Base materials: A comprehensive mechanical assessment (hardness, tensile, indentation, impact tests) and microstructural characterisation (light optical microscopy (LOM), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction (XRD) analysis) of base components (made by A617B, A617B OCC, A625, A263), as new material batches or priory exposed in the COMTES700 loop (without overlapping with the COMTES700 tests), manufactured by different process routes (forging, casting, extrusion, pilgrim, HIP) and with different sizes and/or wall thicknesses.

Task 4.1 Welded joints: A comprehensive mechanical assessment (hardness, tensile, impact tests) and microstructural characterisation (LOM, SEM, TEM, XRD analysis) of welded joints (similar and dissimilar), produced by different welding procedures (Orbital TIG welding - cold wire, Electrode welding, TIG narrow gap welding - hot wire) and with or without pre welding heat treatment. Post weld heat treatment will applied be always.

Task 4.3 Simulation of in-service exposure conditions: Specimens from the creep test program will be adopted for indentation tests to obtain information on mechanical properties. TEM examinations (head and gauge length) at different times and temperatures to evaluate on base metals and in weld metals or HAZ (**H**eat **A**ffected **Z**one), for the welded joints, in order to assess and quantify the strain-induced precipitation effect on overall microstructure evolution (measured in terms of precipitation evolution and coarsening, formation of new phases).

Task 4.4 Dismantled components: A comprehensive mechanical assessment (hardness, tensile, indentation, impact tests) and microstructural characterisation (LOM, SEM, TEM, XRD analysis) of exposed base metals and welded joints (after dismantling) will be performed.

Task 4.5 Welding repair: A comprehensive mechanical assessment (hardness, tensile, indentation, impact tests) and microstructural characterisation (LOM, SEM, TEM, XRD analysis) of the welded joints carried out on in-service exposed pipes taken from COMTES700, will be performed.

Task 4.6 Creep Assessment program: A creep test program will be carried out to characterize the long-term behaviour of the different base metals and welded joints (similar and dissimilar) produced by different WPS (**W**elding **P**rocedure **S**pecification), as well as, the effect of pre-/post- weld heat treatments, giving indication on the stress reduction factor to be applied for the industrial components.

It is foreseen to share the work within all tasks among CSM, VGB and TUD according to the corresponding resources.
An unique combination of mechanical (instrumented tensile tests or special indentation procedures from RT to 800°C, hardness and micro hardness indentations, etc.) and metallographic investigation techniques (LOM, SEM with X-ray microanalysis (energy-dispersive spectroscopy, EDS), EF-TEM incl. scanning transmission electron microscopy (STEM), XRD) have been selected and applied.
Data generated and metallurgical evidences correlated to the mechanical behaviour of laboratory samples and full-scale components will be critically analysed and evaluated in order to identify main damage mechanisms in long-term service exposed components. This evaluation will be shared with the other partners and results will be made available to WP 2, WP 5 and WP 6 to provide a basis for design, operations and repair methods on future 700°C power plants.
The key purpose of WP 4 is that all results and findings out of the operation of the TF will be compiled and evaluated. Based on this assessment the partners will have the necessary conclusions for engineering, designing, manufacturing and commissioning in order to start with the erection of a 700°C power plant. Therefore, VGB will integrate all

expertise familiar with the 700°C technology in Europe as Laborelec (Belgium), Fraunhofer institutes (Germany) or others.

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