CEFDA05-1275

Task Title: TW5-TES-CRYO-1: DESIGN AND LAYOUT OF CRYOPLANT AND CRYODISTRIBUTION SYSTEM

INTRODUCTION

The main objective of this task was to provide cryogenic information to the ITER project for further progress in the design of the machine.

The task was subdivided into the following subtasks:

Subtask 1: Design and layout of the ACB (Auxiliary Cold Boxes) for magnet structures;
Subtask 2: Design of a test loop to assess the mitigation of pulsed heat loads and validate the design of ACB for magnet structures (in collaboration with FZK);
Subtask 3: Analysis of cryoplant operational modes for all ITER operation scenarios including standard operations;
Subtask 4: Thermo-hydraulic modelling of the torus cryopump.

During the signature of the contract it was planned to work on the neutral beam cryopump. Due to the lack of input concerning the design of this component, it was not possible to perform the work foreseen. Therfore it was decided, in agreement with EFDA, to work on the prototype of the torus cryopump.

2006 ACTIVITIES

ACB FOR MAGNET STRUCTURE

The goal of this cold box is to provide supercritical helium at 4.2 K to cool the structures of the toroidal magnets (TF magnets) for the identified modes (normal and abnormal). The main characteristics of this box are:
- The cryoplant provides supercritical helium. This gas is expanded in the bath of the cold box to produce liquid. This liquid is used for the cool down of the TF structure and inside the bath a heat exchanger connects thermally the bath and the primary supercritical helium loop of the structure.
- It includes different types of components like: a boiling liquid bath, a heat exchanger, a circulating pump, a cold compressor, a set of cryogenic valves,…
- It is located inside the tokamak building with important constraints of compacity.
- It is 4 m in diameter, 6.3 m in height for a weight of 35 t.
- The compensation system for thermal contraction (300 – 4K) is adapted to avoid the use of bellows. The thermo-mechanical calculations validate the mechanical design and satisfy the cryogenic valve requirements (low displacement).

Figure 1 (CATIA model) presents the result of this study.

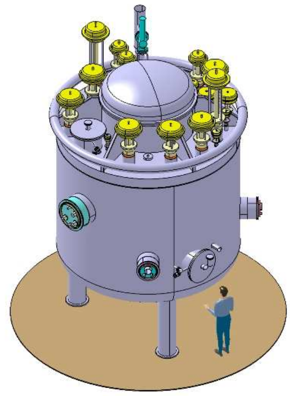

Figure 1: ACB "Structure"

TEST LOOP DESIGN

Due to the pulsed operation of the ITER tokamak, the refrigerators have to face strongly varying heat loads, which is very demanding for such systems. A load smoothing device has been proposed by the ITER team which needs to be validated. To do this, a scaled-down experiment (similitude) is proposed and studied in this subtask.

The work carried out can be broken down into several steps - first of all data concerning the cryogenic circuit were collected. Then calculations of the thermo-hydraulic behaviour of the fluid in all sectors were performed in order to be able to choose the similitude conditions and the scale of the test loop.

Once these steps were validated and the scaling chosen, the different components of this test facility were defined. The resulting scaling ratio was chosen to 60.
It is a compromise between the cost reduction of the experiment and the possibility to validate some components like heat exchangers with an acceptable scale effect.
Figure 2 shows a pre-design of this loop.

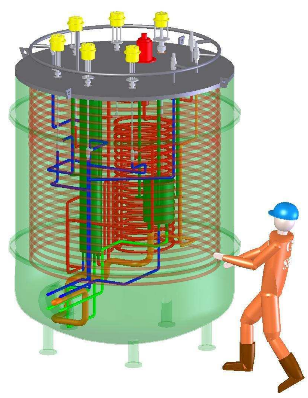

Figure 2: Preliminary design of the test loop (2.1 m in diameter)

ANALYSIS OF CRYOPLANT OPERATIONAL MODES

This study presents an analysis of the ITER cryoplant and cryodistribution operational modes:

- Based on the last published cryogenic Process Flow Diagram (PFD) and taking into account the heat loads related to the magnet system and the cryopump system, the first part of this study was dedicated to the verification of the relevant normal operating scenarios for the typical ITER operating states.
- The second part of this report concerns the inventory of the abnormal operating modes which distinguish the abnormal modes coming from the magnet system from those generated by the cryoplant itself.

During this analysis, some improvements and modifications of the overall ITER PFD have been proposed and an updated PFD is now available. The Process and Instrumentation Diagrams (PIDs) of all the cryostat parts of the cryodistribution system were modified and updated accordingly in the frame of this task.

TORUS CRYOPUMP

This study has been divided into two parts:

A VINCENTA model for the calculation of the pressure drops in the prototype torus cryopump (PTC) (see figure 3) was performed. It was then compared in normal operating conditions with data provided by the laboratory in charge of the design and the test of this component: FZK and a good agreement between measurements and calculations was obtained. This step was necessary to verify that the pressure drop will be acceptable for the operation of the cryoplant and cryodistribution, and especially for the cool-down and the warm-up phases. It will also be possible to investigate the behaviour of the PTC in accidental situation. This model is now ready for these types of calculation.

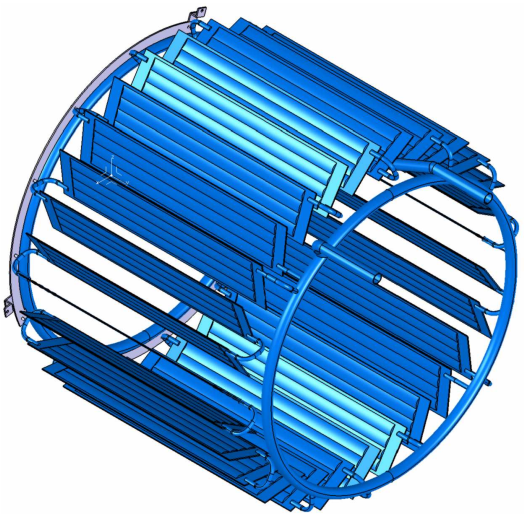

Figure 3: View of the torus cryopump

The second part of the study was dedicated to the analysis of the repartition of the helium flow in the pipes used for the PTC cryopanels. This study was performed by numerical simulation with the ANSYS/FLOTRAN code. These panels are ITER-relevant in terms of geometrical design. Figure 4 shows the location of the helium inlet/outlet pipes. A calculation of the mass flow in the 4 parallel channels of the cryopanels in this configuration was done: it shows that unbalanced flow among the channels. Therefore some proposals were made to modify the geometry of the inlet/outlet pipes in order to restore comparable flows in the four channels.

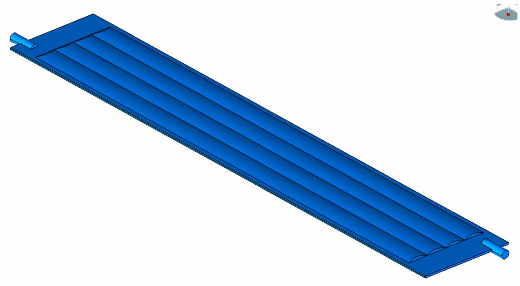

Figure 4: View of a cryopanel

CONCLUSIONS

ACB STRUCTURE

The conceptual design of the ACB structures has been successfully performed. Due to the geometric constraints and the number of devices to install, the result is very compact. As for others ACBs, the compensation system for thermal contraction (300 – 4K) is adapted to avoid the use of bellows which permit to increase the reliability of the system.

TEST LOOP

A load-smoothing device was proposed by ITER team by using a by-pass valve on the TF structure. A validation method was studied by using a reduced scale experiment. The choices done for the design of this loop will permit to simulate exactly the ITER scenarios and the result will be directly representative of the ITER behaviour. A compromise between the reduction cost and the scale effect has been done and a similitude ratio of 60 was decided. A preliminary design was performed in order to estimate the exact size of the experiment.

The same experimental tool will also be useful to test other methods or strategies to smooth the impact of pulsed loads on the refrigerator in order to optimize the global efficiency of the system.

CRYOPLANT OPERATIONAL MODES

The major conclusion about this analysis of cryoplant operation modes is the proposal for a dedicated 4.5 K refrigerator module for the cryopump system, which can be operated at every moment and more particularly in order to pump the cryostat vacuum vessel before the cool down of magnets or to warm up magnets keeping the insulation vacuum in these devices.

An upgrade of the overall ITER PFD was done to take into account the result of this analysis. A new version of that document is now available.

TORUS CRYOPUMP

A Vincenta model has been developed for the pressure drop calculation inside the torus cryopump, it has been validated by data from FZK and it is now ready for other calculation type (cool down or warm up for example).
For the inputs/outputs pipes supplying the cryopanels, an ANSYS/FLOTRAN model was performed during the study. It showed that improvements in the design of these pipes were mandatory, to obtain an appropriate distribution of the helium flows among the channels. Some proposals were made.

REFERENCES

[1] Analysis of the ITER Cryoplant Operation Modes – D. Henry, J.Y. Journeaux, P. Roussel, F. Michel, J.M. Poncet, A. Girard, V. Kalinin, P. Chesny – SOFT 2006 – Warsaw (Poland)

[2] Performance of the Cryogenic Test Facility at CEA Grenoble between 1.5 K and 4.5 K – P. Roussel, M. Bon Mardion, A. Girard, J.M. Poncet, B. Rousset – ICEC 21 – Prague (Czechoslovakia)

REPORTS AND PUBLICATIONS

[1] Final report of the subtask 1: design and layout of the ACB (Auxiliary Cold Box) for magnet structures – P. Chesny and CEA cryogenic working group – SACM/LCSE T-0000 003

[2] Final report of the subtask 2: design of experimental loop to assess mitigation of pulsed heat loads – S. Maze and B. Rousset – Note SBT/CT/06-85

[3] Final report of the subtask 3: analysis of the ITER cryoplant operational modes – D. Henry and CEA cryogenic working group – CRY/NTT 2006.007

[4] Final report of the subtask 4: Numerical simulation of prototype torus cryopump panels – R. Vallcorba – CRY/NTT 2006.007

[5] Final report: Design and layout of cryoplant and cryodistribution system (task agreement ITA 34-06) – J.M. Poncet and the CEA cryogenic working group – Note SBT/CT/06-86

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Task Title: TW5-TES-EISS5: EUROPEAN ITER SITE STUDIES 5 CADARACHE

INTRODUCTION

The most important fact in 2006 was the signature of the agreement on the establishment of the ITER international fusion energy organization for the joint implementation of the ITER project, on the 21st of November in Paris.

The Agence ITER France (AIF) was created in October 2006, as a CEA service with an independent budget. AIF is the interlocutor of International and European legal entities, in charge in particular of site preparation and fund collection. Moreover, it manages EISS-5 tasks, under EFDA responsibility.

EISS activities have their own steering process with regular meetings and exchange of information with EFDA and the European Commission. The EISS-5 contract covers the period from 21st December 2005 to 21st June 2007. An intermediate deliverable (reference GA51-DEL-2006-0001) refers to 30 specific deliverables covering the main topics of the EISS-5 contract. The reader who would wish extensive information is requested to ask for these documents.

The following pages are given for reminder and are covering only the main aspects of the contracts. The EISS project (and its corresponding tasks) is, as for previous years, structured to progress on all items on the critical path, with an emphasis on the licensing schedule.

2006 ACTIVITIES

SAFETY & LICENSING

The required documentation is being prepared for submittal to the French Safety and Licensing Authorities. The writing of these documents (Preliminary Safety Report, files for the INB public enquiry…) is progressing, in strong partnership with the ITER Organization, and is supported by studies performed at European level in parallel.

The Preliminary Safety Report is being reviewed, following a wider ITER project review. The R&D launched within the framework of EISS-5 also allows to complete and detail the writing of several chapters.

Within the framework of EISS-5, several studies were performed to support this Safety and Licensing area, for example the aspects concerning an ITER waste management strategy.

All Safety and Licensing tasks are also covered by the ITER Task Agreement n° 81-15 between EFDA and the ITER Organization.

IN-FENCE STUDIES

On the 13th of July 2006, the ITER Preparatory Committee agreed to establish a working group comprising the Host State, the Host Party and the ITER Organization to validate decisions on site preparations (so called Site Preparation Coordination Group).

Simulations of drainage of the ITER site are being carried out, taking into account the results of local measurements.

Following preliminary seismic studies, a programme for qualification of the seismic isolation pads is being performed.

Different possibilities were studied to decouple PF coil manufacturing from the cryoplant, releasing a possible critical point in the ITER schedule. The results of these studies were used by EFDA to suggest to the ITER Organization an alternative to the generic design.

OUT-FENCE STUDIES

For transportation interfaces, a packaging study for PF Coil n°1 was performed in order to fit within the ITER Site Requirements that are already taken into account by the Regional Direction for Equipment to adapt the itinerary from the harbour to the site.

Several studies allowed to suggest design criteria and applicable standard documents for electrical networks on the ITER site. Moreover, an inventory of reference and regulations to comply with for electrical equipment to be delivered to France is being compiled.

Specifications of external networking needs for the ITER site were also prepared for both internet and telecommunication aspects.

SOCIOECONOMIC ASPECTS

The last step of the public debate consisted in the official publication on the 10th of October of the modalities of continuation of the ITER project.

Socio-economic activities are carried out in public information and communication, as well as in developing strategies to grant support from industries, universities, research establishments.

A “Welcome Office” is already operational to welcome the new ITER staff and ease their relocation, including housing, administrative support and French language courses.

REPORTS AND PUBLICATIONS

EISS-2 final report delivered in March 2004
n° GA1-DEL-2002-0018 rev2

EISS-3 final report delivered in June 2004
n° GA31-DEL-2003-0004

EISS-4 intermediate report delivered in March 2005
n° GA41-DEL-2004-0006

EISS-4 final report delivered in March 2006
n° GA41-DEL-2004-0008

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