

MEETING MINUTES

To: All participants
From: Xavier Sarasola

Date: May 8th, 2020
Subject: EDIPO progress meeting

1. Participants

- CERN: Luca Bottura, Douglas Martins Araujo, Juan Carlos Pérez, Gijs de Rijk.
- EPFL-SPC: Pierluigi Bruzzone, Xavier Sarasola, Kamil Sedlak, Evgeny Solodko.
- F4E: Alfredo Portone, Pietro Testoni.

2. Meeting documents

- Meeting documents are uploaded to the following Indico site: <https://indico.psi.ch/event/8854/>

3. Agenda

3.1. Discussion of the Work Plan

- The work plan is approved by the meeting participants with the following comments:
 1. Include the confirmation (or update) of the current baseline as a milestone. The tentative date for that meeting is July 2020.
 2. Include the functional specification of the magnet as a reference or annex to the text.
- The work plan will be also complemented with details of the helium vessel design.

3.2. Eddy current analysis during quench

- P. Testoni presented an analysis of the evolution of the eddy currents in the 4-coil design during a quench. The study also includes the evolution of the Lorentz forces and power loss in different magnet components (including the buffer stainless steel plate).
- In EDIPO2 the magnetic field is larger and the outer radius of the yoke is smaller compared to the former EDIPO. This results in a larger flux leaking out the magnet assembly, which is undesirable (significant currents circulating through the outer cylinder during a current dump). Eddy currents in facility components beyond the magnet outer shell (i.e., He vessel) are not considered in this model.
- The analysis shown in the slides assumed the outer shell was made of stainless steel. After the meeting, the model was run again assuming an aluminum outer shell. The slides posted in the Indico site include both analyses: steel and aluminum shell. The presentation of the aluminum outer shell reports the power loss in all passive structures as agreed in the meeting.
- The studies assumed an exponential decay of the current with a time constant of 0.2 s. The study of the case where the magnet is connected to the dump resistor is suggested.

3.3. Progress on the conceptual design activities at CERN

- D. Martins showed the status of the activities at CERN in three presentations:
 1. A semi-analytical model has been developed for the computation of the eddy currents in the buffer plate located between coils in the 4-coil design. The agreement with P. Testoni's model

is satisfactory. The contribution of the Joule losses in the steel plate are planned to be included in the hotspot calculations performed with LEDET.

2. The status of the quench protection studies was presented showing that a protection approach based on energy extraction is able to protect the 4-coil design alternative. The hot spot temperature seems to be acceptable. Large temperature gradients are observed in the coils.
3. The status of the 3D mechanical analyses of the 4-coil design alternative was also presented.

3.4. Alternative design without poles

- X. Sarasola presented an alternative design of EDIPO2 where detachable winding poles are used and the titanium pole is eliminated.
- One goal of this design is to have a stress-free test well. The vertical load is not transmitted to the test well and only moderate lateral preload is applied. During powering a gap of < 1mm opens between the test well and the coils. This is not a concern in a test facility like EDIPO, where no strict field quality requirements have to be met.
- Since the coil turns are closer to the magnet aperture, this alternative without poles results in a more efficient use of the conductor cross-section than other designs considered so far. The stress in the coils remain below 120 MPa almost everywhere in the coil (except a peak of 147 MPa in the low field side).
- CERN comments that this concept may indeed have potential for better magnet performance, as it eliminates the issue of pre-compression at very high field. Promising results were obtained from an 11 T coil with modest pre-load, albeit in a completely different configuration (cos-theta and collars), as well as similar results on the SMC program. An R&D program is already launched at CERN to study the use of detachable poles and lack of pre-load in short racetrack coils (SMC coils).
- No evident showstoppers are identified in this magnet design proposal, at least on the 2D magnet cross section, but CERN also comments that the details and the 3D may bear difficulties (e.g. magnet assembly solutions and tolerances, end turns), and experience and validation should be gained with small coils before committing to a large investment.

4. Next steps

- Some of the open issues identified in the previous meeting have been addressed, others remain unfinished, particularly those concerning the current baseline design:
 - The axial pre-load of the coils. It does not seem to be sufficient to avoid pole detachment.
 - The aperture after cool-down seems to be slightly smaller than required.
 - The wedge shows a large peak of stress
 - Concentration of stress has been identified in coil #1 when the wedge opens.
- Additional open issues were identified and analyses were suggested in this meeting. They include the following:
 1. Work Plan (SPC): P. Bruzzone / X. Sarasola will provide an updated functional specification, which will serve as basis for the criteria to confirm (or update) the current baseline design.
 2. Eddy currents:
 - F4E will study the case where the magnet is connected to the dump resistor.
 - SPC will provide the maximum allowable outer diameter of the magnet assembly in order to minimize the flux leakage causing the eddy currents in the outer shell.
 3. Alternative design without titanium pole (SPC and CERN):
 - SPC will elaborate on this proposal, including the design for the coil ends.
 - A quench protection analysis is also desirable (can E. Ravaioli do this analysis?)
 - During the calendar week 22 (last week of May), Juan Carlos Pérez will provide input from the SMC program, which shall be considered in this design alternative.
- The next progress meeting is scheduled for June 4th at 2 pm.