VERTICAL ELECTRO-POLISHING AT CEA SACLAY: COMMISSIONING OF A NEW SET-UP AND MODELING OF THE PROCESS APPLIED TO DIFFERENT CAVITIES

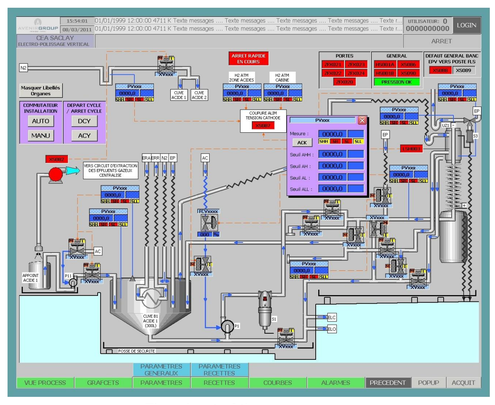
F. Eozénou, S. Chel, Z. Wang,Y. Gasser, J-P. Poupeau, C. Servouin

CEA,DSM/Irfu/Service des Accélérateurs, de la Cryogénie et du Magnétisme, CEA-SACLAY, F-91 191 Gif-sur-Yvette.

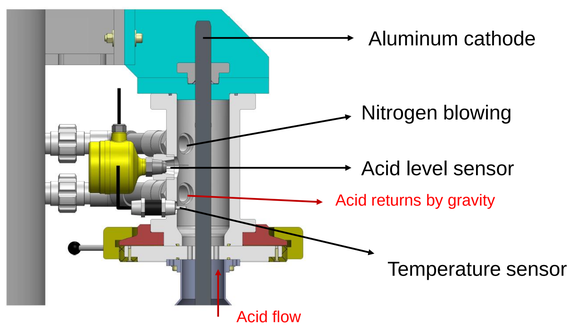
Introduction : High performance required for elliptical low beta cavity makes the electro-polishing desirable for their surface treatment. For large dimension cavities, the EP treatment in vertical configuration (abbreviated as VEP) is more appropriate. A VEP set-up has been designed at Saclay for the electro-polishing of such cavities. Compared to existing 9cells VEP set-ups, the electrolyte will be circulating and the process automated, including several safety procedures.
In addition, VEP has been modeled using COMSOL software with 2D axi - symmetry configuration for 2 different cavities: 9Cell ILC and 5Cell SPL cavities. Different cathodes have been designed to optimize fluid and Electric Field distribution during VEP. Respective results will be presented.

PRESENTATION OF THE SET-UP

- Cavity EP'ed in Vertical configuration
- Designed for large cavities
- Cavity dressed on dedicated table
- Circulating acid (1 pump)/Draining by gravity
- Cavity EP'ed in ventilated cabinet
- 300L acid capacity
- Process automated/safety procedures
- Available Electrical power: 20V – 1500A
- Nitrogen blowing
- Mainly Teflon/PFA made

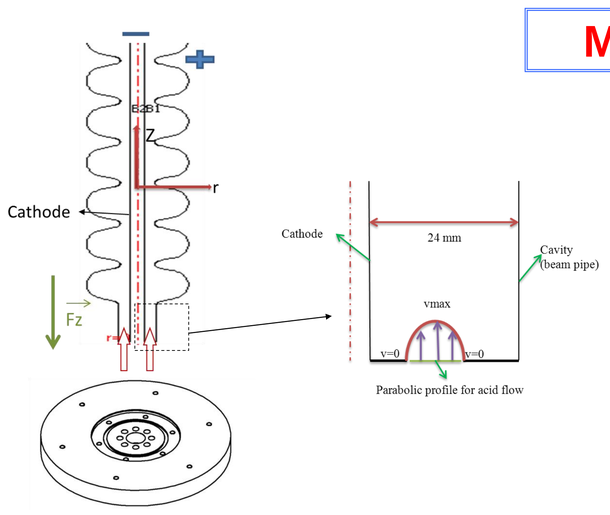


Flowsheet of the process



Upper part of the process

MODELING WITH COMSOL Multiphysics



Generalities

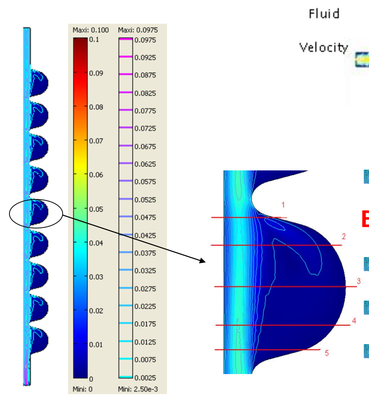
- 2D axisymmetry model

Fluid Dynamics

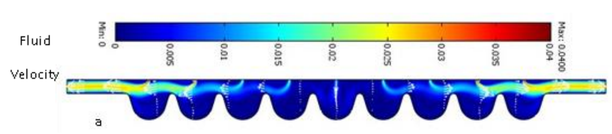
- Entering crown of acid considered
- Navier-Stockes (laminar) equation
- No slip at the walls

Electric field

- 15V voltage
- Cathode w/wo insulation



Result with vmax=0.2m/s

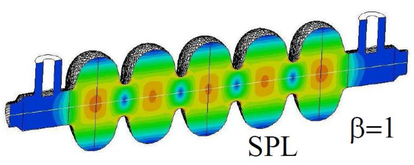


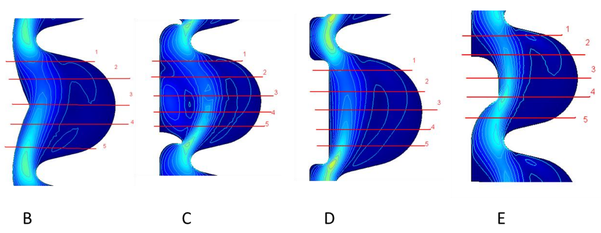
- Contrary to Horizontal EP, flow similar in each cell

BUT:

- Fluid principally flows in the beam pipe
- Need to improve the process (cathode shape)
- Study in the central cell under 5 locations

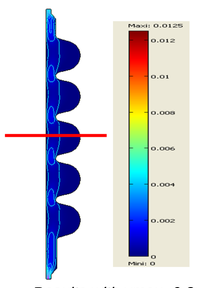
ILC 9Cell Vs SPL 5Cell Cavity



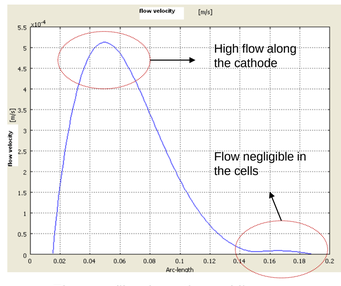


- 4 alternatives shapes tested
- Protuberances make it possible to increase flow in cells
- Shape C improves uniformity by 33%
- Shape D improves fluid velocity in the cell by 39%

Fluid Dynamics



Results with vmax=0.8m/s



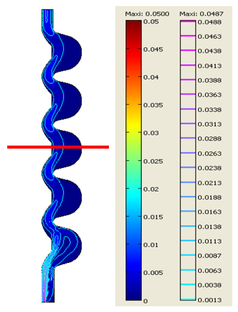
Flow profile along the red lines

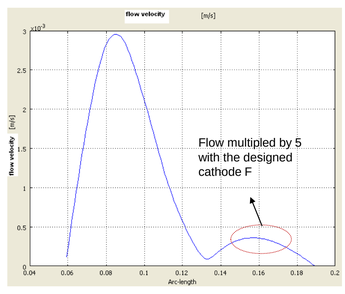
- Less favorable compared to ILC
- Fluid velocity very low in the cells
- Rod cathode must be modified

The Risks:

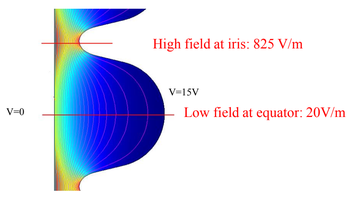
- Low removal rate
- Niobium saturation at the cavity surface
- Deterioration of the surface

Different cathode geometries For better fluid distribution

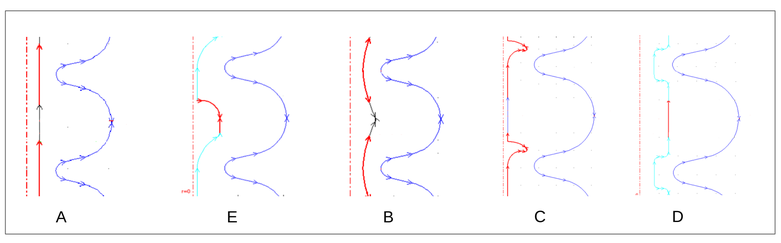




- SPL cavity modeled without taper
- For larger protuberance (shape F)
- Narrowed section increases flow
- Fluid velocity multiplied by 5 in cell

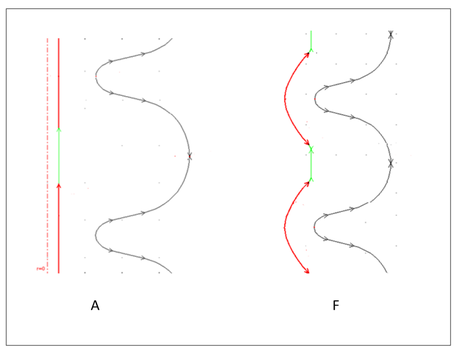


Potential distribution during VEP



Shape	Insulation	E_i (V/m)	E_e (V/m)	E_i/E_e
A	No	825	20	41.2
B	No	816	18	45.3
C	No	913	33	27.7
D	No	1138	43	26.5
E	No	600	35	17.1
A	Yes	200	50	4.0
B	Yes	96	15	6.4
C	Yes	225	30	7.5
D	Yes	128	35	**3.7**
E	Yes	240	32	7.5

- Electric field modeled for shapes A → E
- Parts in front of iris insulated
- Comparison with non insulated cathodes
- Shape D with insulation favorable



- Electric field modeled with Shape F
- Tests with or without insulation
- Insulated F cathode responsible for improvement

BUT:

- Lower removal rate expected

Shape	Insulation	E_i (V/m)	E_e (V/m)	E_i/E_e
A	No	292.7	8.1	36.1
F	No	409.5	21.7	18.9
A	Yes	80	5.7	14.1
F	Yes	111.7	19.0	**5.9**

Acknowledgements: **This work was funded by EuCARD, ILC HiGrade and ASTRE Programs.**

Conclusion: The Electro-Polishing in Vertical configuration is well adapted for large elliptical cavities. A dedicated set-up has been commissioned at Saclay. The VEP will be achieved with circulating acid through an automated process. However, proper parameters must be carefully chosen in order to achieve satisfactory treatment. Modeling with COMSOL allows investigating appropriate cathodes designs. The studied cases did not take into account parameters such as gas forming at the cathode and the cavity surface. Once the first cavities electro-polished, results will be compared with models, for full understanding of the process.