ISTC project K-1265:

Experimental study of core melt in-vessel retention

IN-VEssel COrium Retention (INVECOR)

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IAE NNC RK

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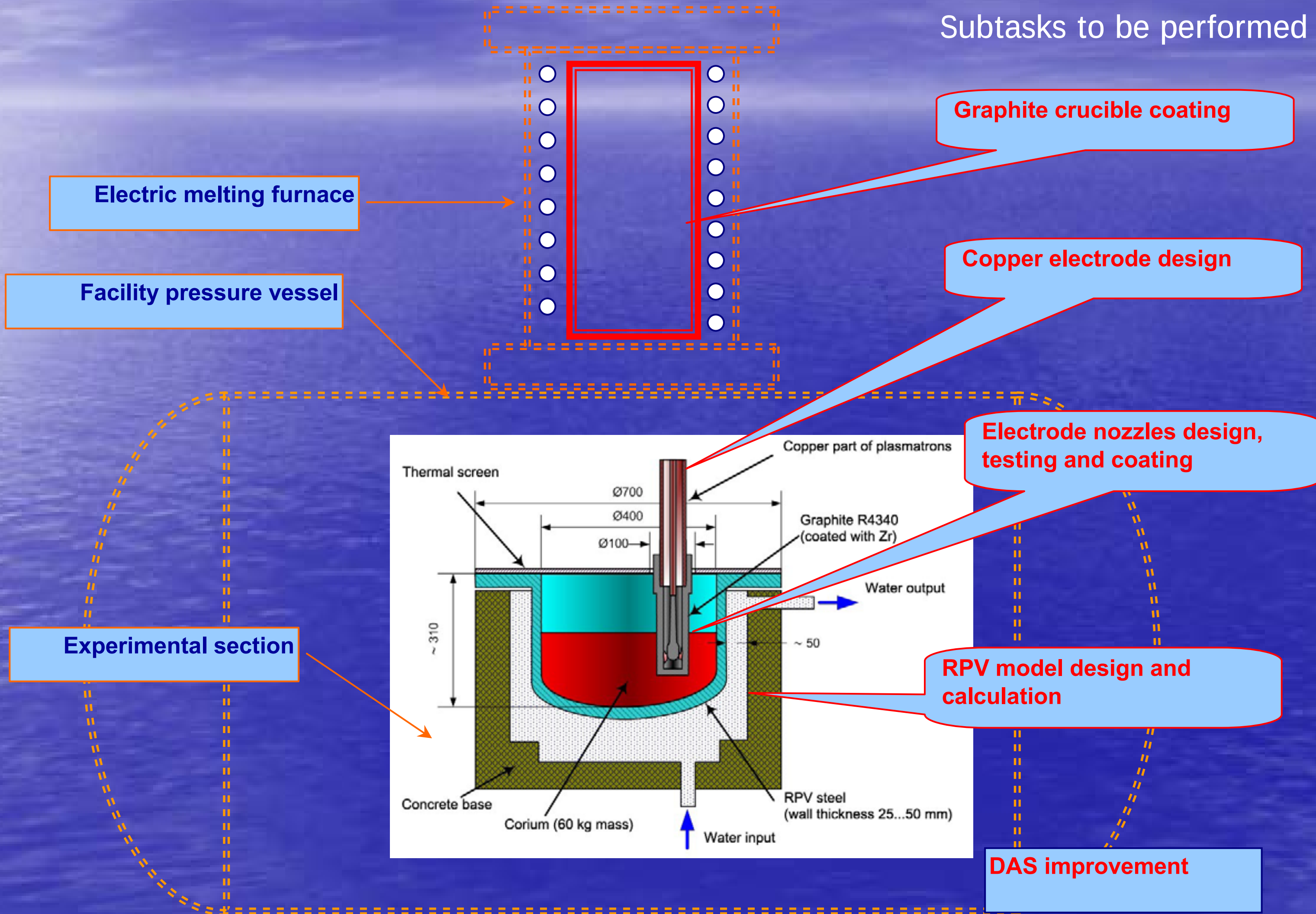
Presentation contents

- Introduction
- Main directions of work and results
    - Testing of Zr-coating technique on large scale crucible inner surface
    - Check of some phenomena of molten zirconium behavior in small-scale experiments
    - Design and testing of device for decay heat modeling (DDHM)
    - Test section (TS) design (RPV model)
    - Small scale test for engineered estimate of RPV model design
    - Pre-calculation of above items
- Conclusions

Introduction

- Project K-1265 has been started from May 1, 2006.
- Operations are fulfilled according to the confirmed Working Plan (for today while there are no terminated operations).
- Ongoing task are:
- Modernization of test facilities, optimization of melting process and simulation of decay heat.
- Calculation support of experiments.
- Post-test analysis.
- Requests for procurement of materials and equipment were sent to ISTC office. Most units of equipment are delivered in IAE.

Major directions of LAVA-B facility modernization

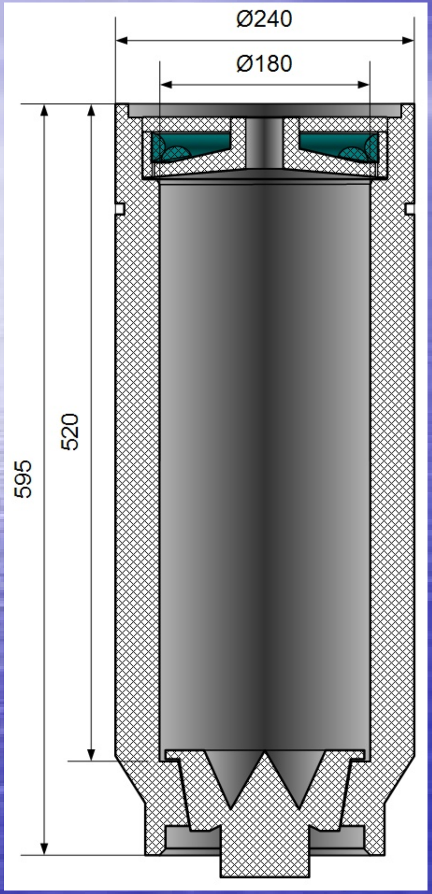


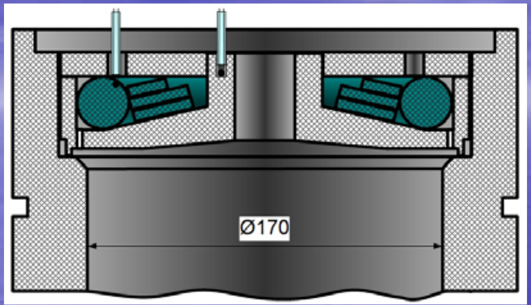
Tests of Zr-coating of large scale crucible

Main differences in heating conditions of large-scale crucible compared with small-scale crucible are:

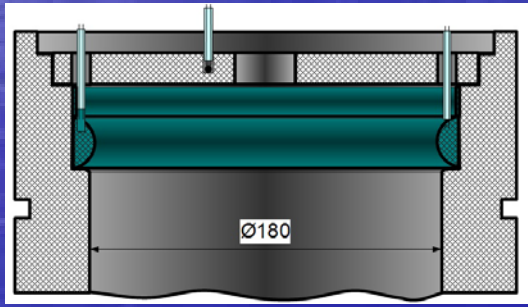
- Presence of temperature gradient along the crucible height
- Very long process of crucible cooling due to big thermal capacity of graphite materials
- Presence of impurities in the gas medium because of presence of a plenty of porous materials in EMF (O_2, N_2)

Tests of Zr-coating of large scale crucible

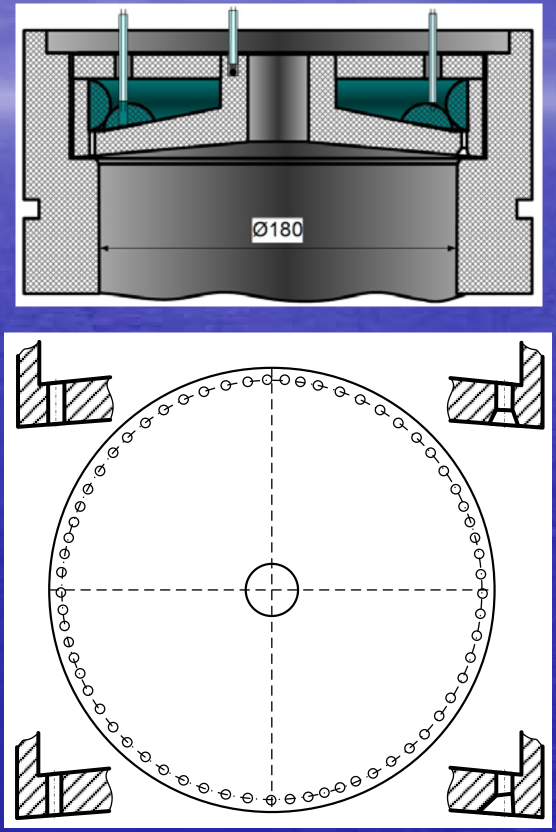




1st test



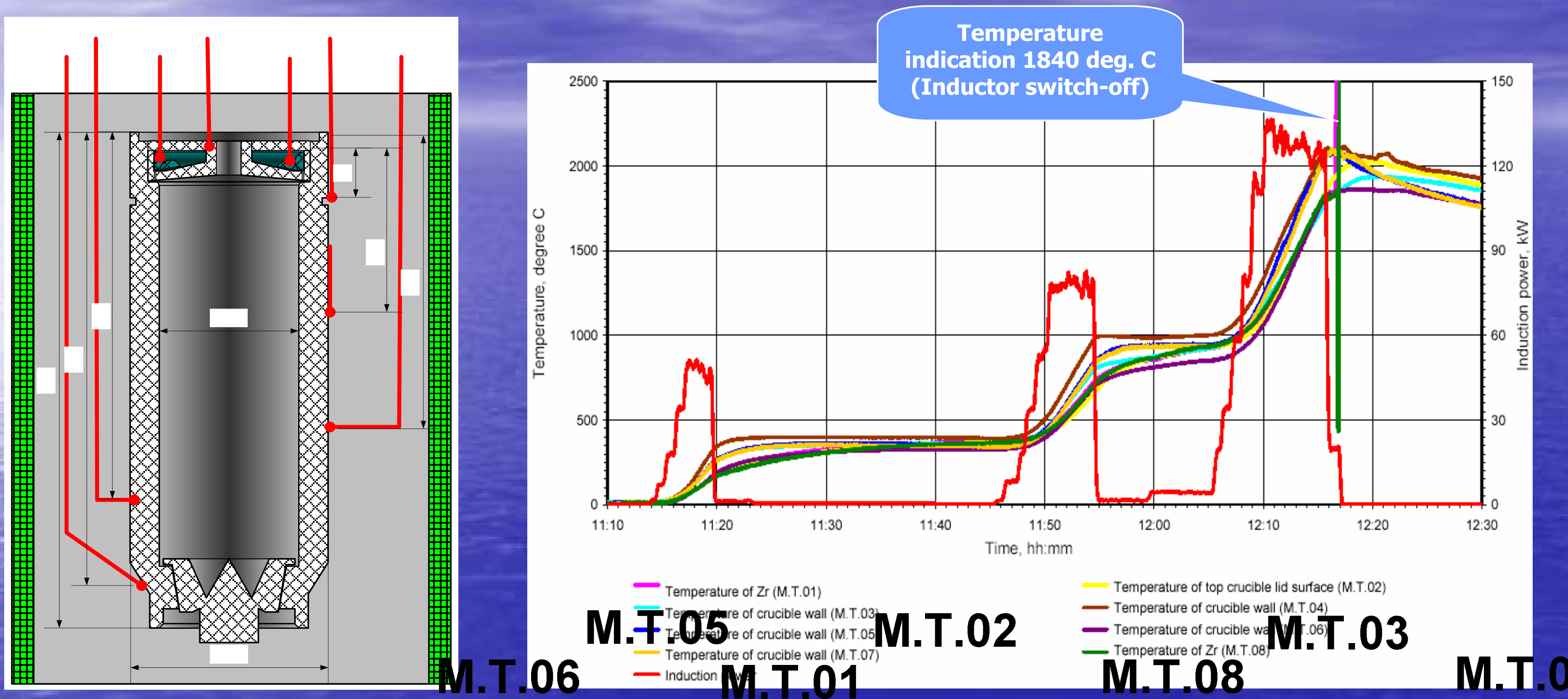
3rd test



2nd test

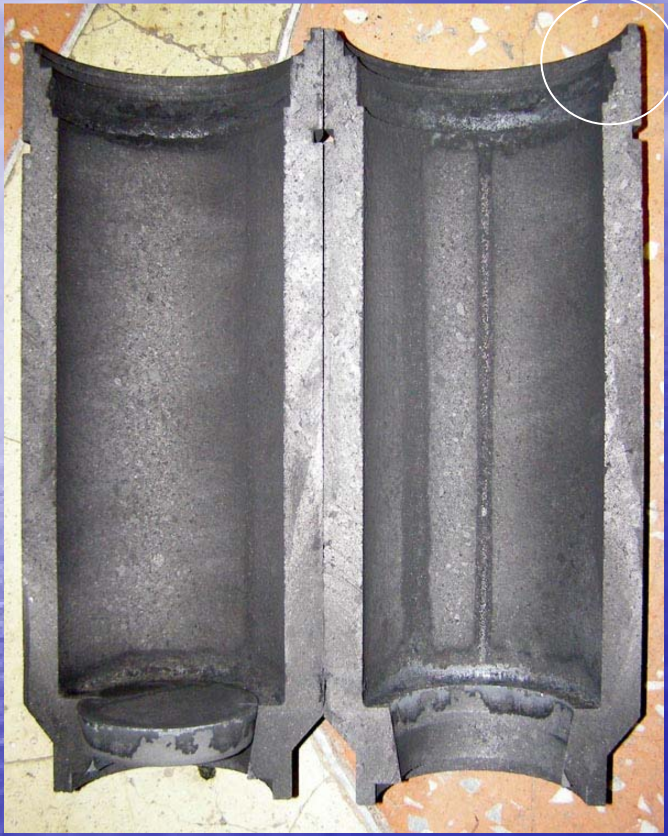
Variants of zirconium initial loading in the crucible

Tests of Zr-coating of large scale crucible



Temperature history of large scale crucible coating (2nd test)

Tests of Zr-coating of large scale crucible

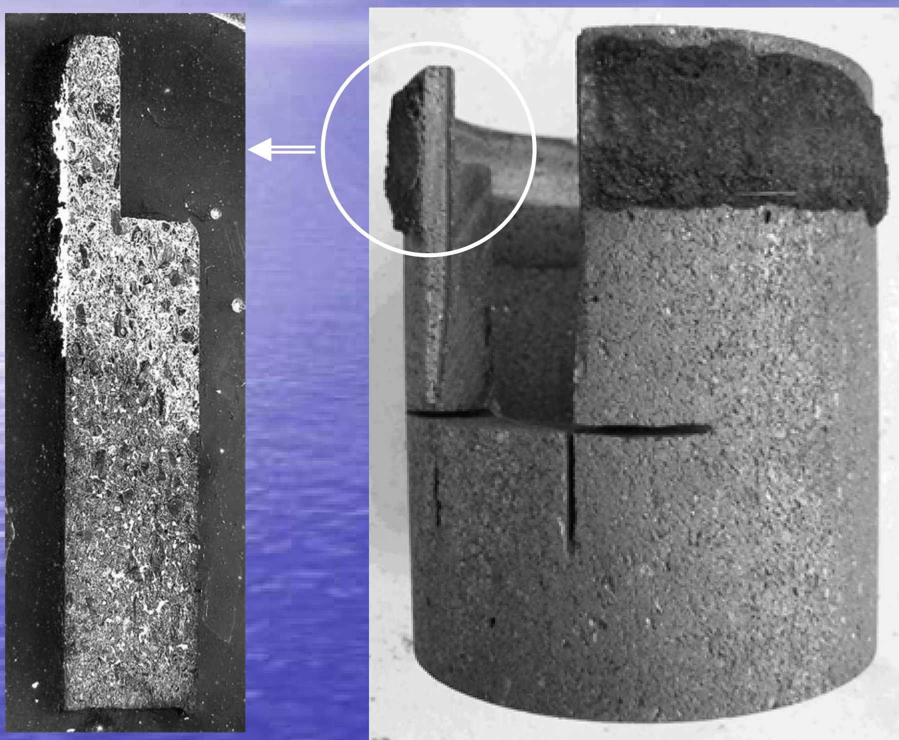


3rd test

2nd test

Results of large scale crucible coating (2nd test)

Small-scale tests on Zr-coating with graphite of different porosity



GMZ-graphite
(porosity >26%)

ARV-graphite
(Porosity <18%)

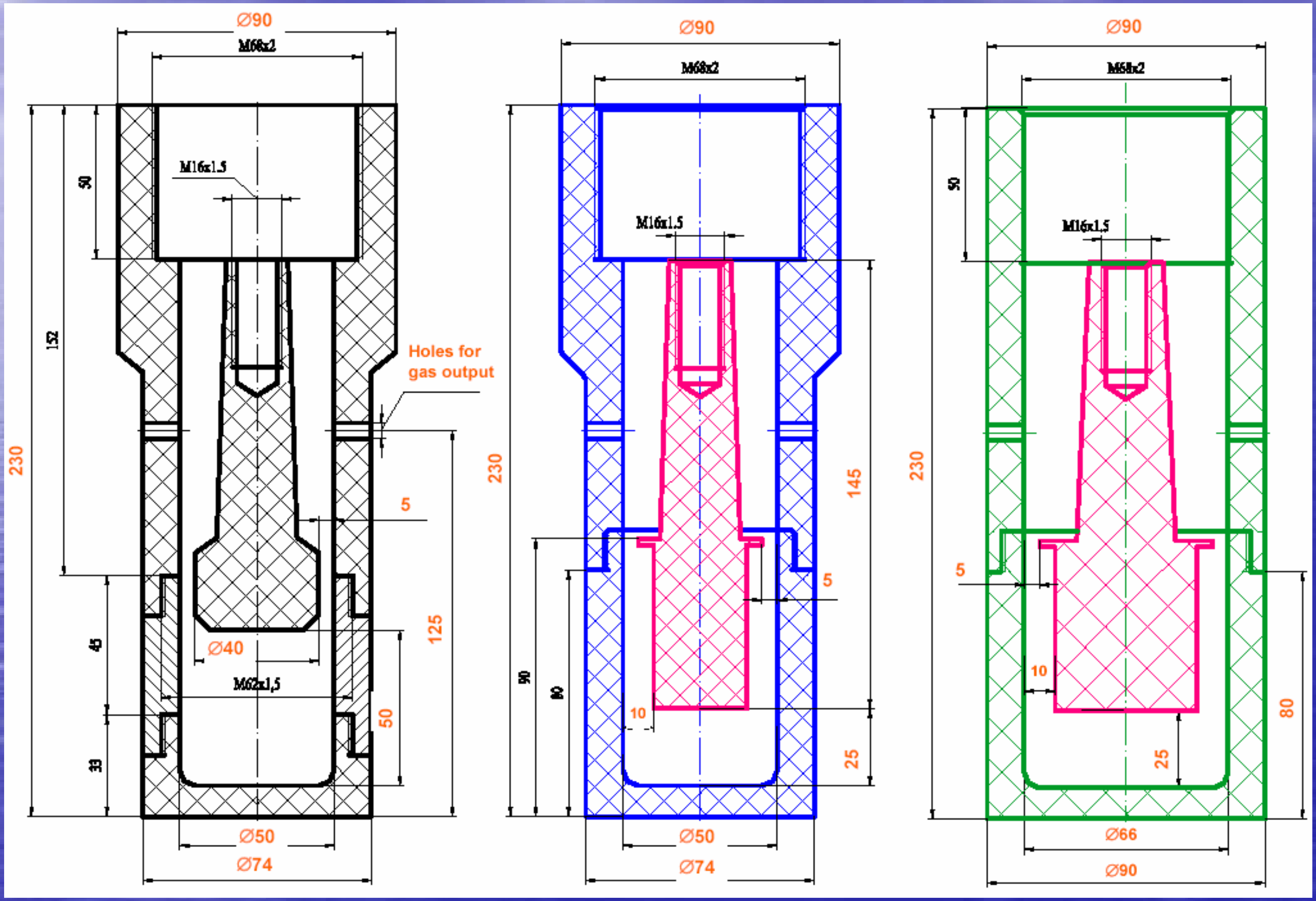
Summary to crucible protection

- Use of graphite with high porosity leads to deep penetration of molten zirconium into crucible wall (up to appearance of zirconium on the outer surface of the crucible)
- Application of graphite with lover porosity allows to obtain the thin film of zirconium on the inner surface of crucible
- It is effectually to use the crucibles with conical inner surface for providing of slow droop of initial zirconium ring as it melt
- Testing of Zr-coating will be continued after receiving of isostatic graphite made in SGL Carbon Group (Germany) with porosity less than 12%
- Idea of conical inner surface of crucible will be tested in small-scale facility

Device for decay heat modeling

- Designing of new plasmatrons is under way (in the concept of new plasmatrons the forced movement of an arc in an azimuth direction and magnification of a resource of nozzles is included). New variants of plasmatrons design are making under sketches and testing for check-out and an improvement of the concept.
- Development of zirconium coating technique on the outer electrode outer surface is under way. Necessary equipment is made and tested.

Concepts of electrode design

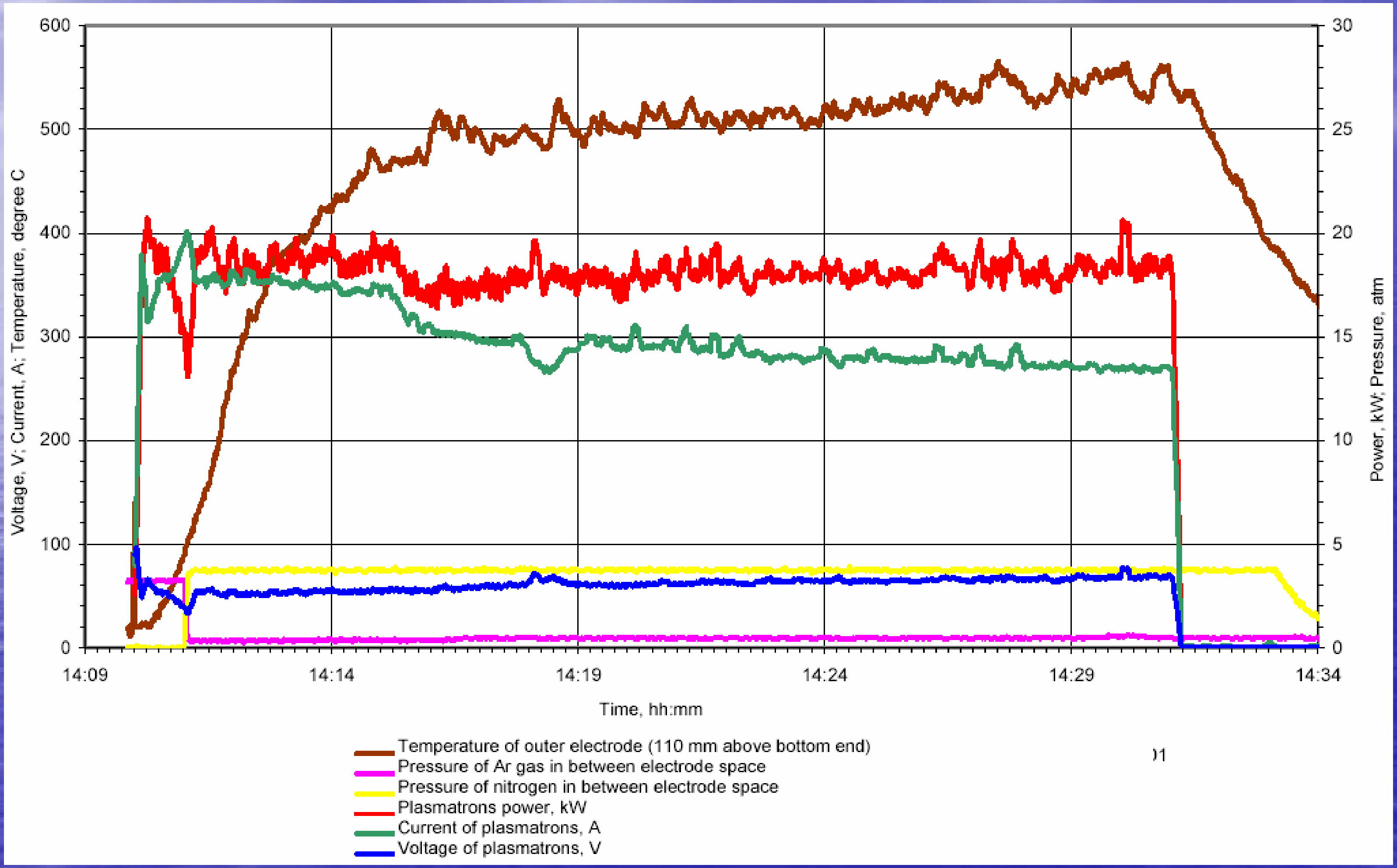


Tested

Tested

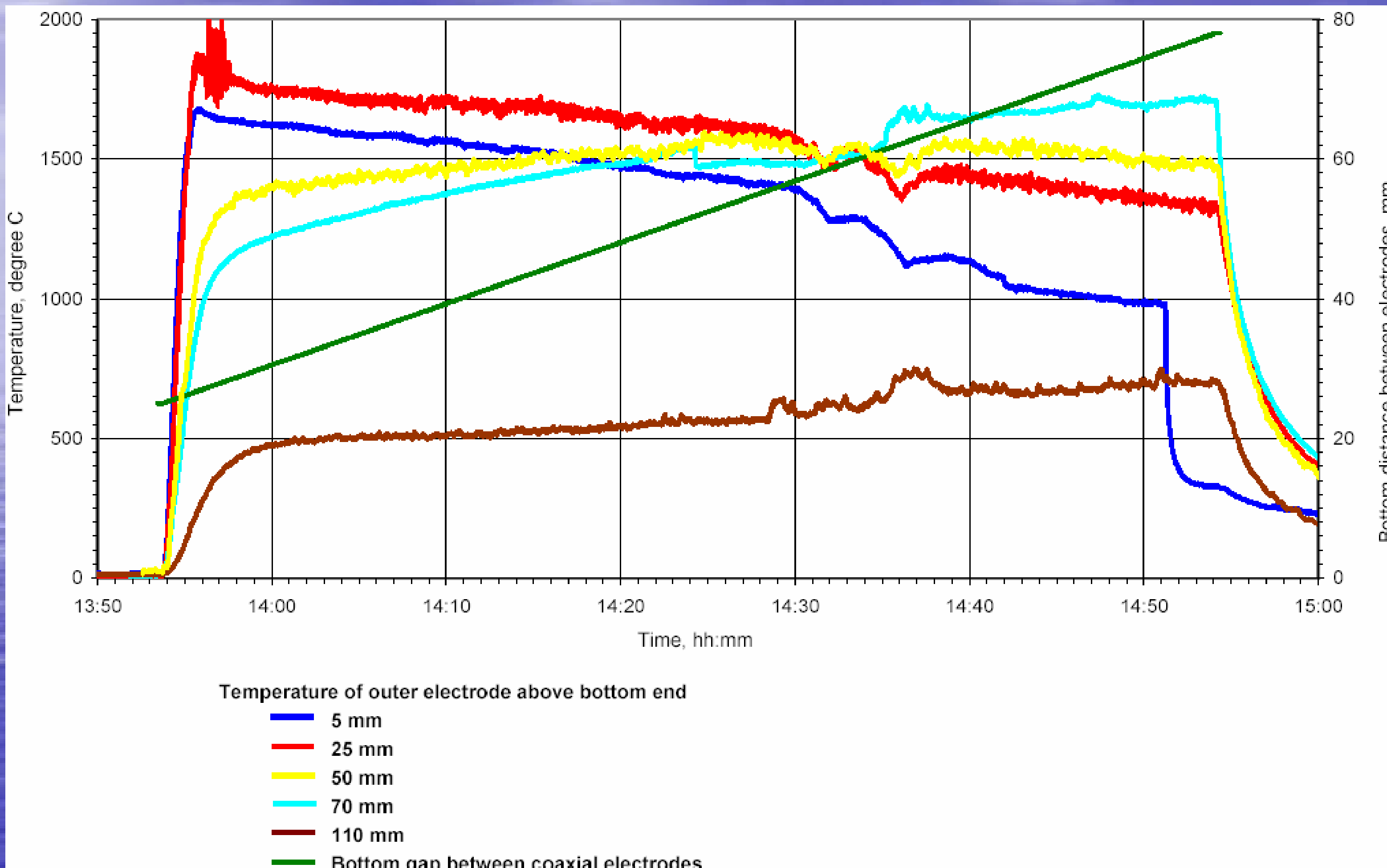
Testing is under way

Testing of composite electrode nozzles



Test parameter variation (30 minutes)

Testing of composite electrode nozzles



Test parameter variation (60 minutes)

Testing of composite electrode nozzles

Outer electrode
3 parts variant

Inner electrode

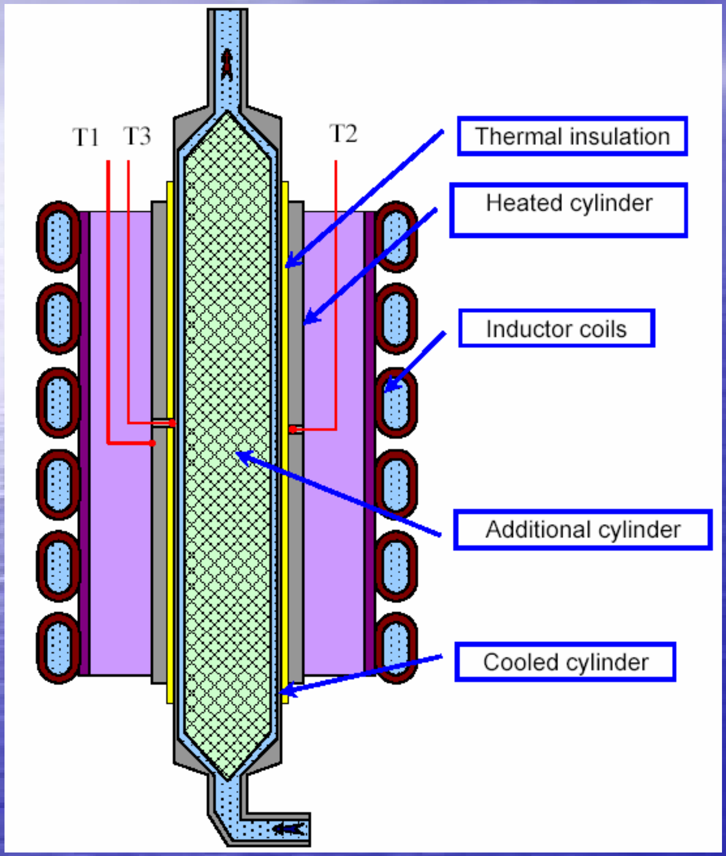
Outer electrode
2 parts variant

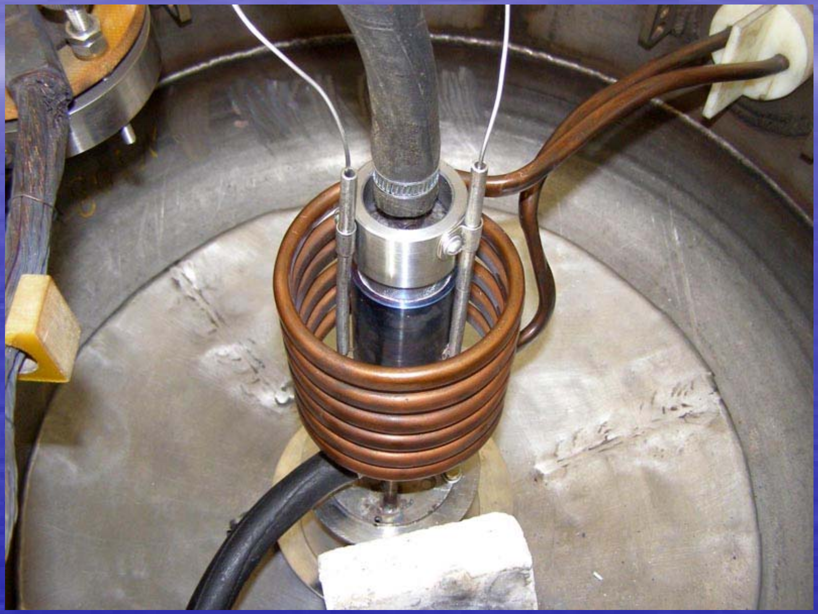
Electrodes view after 1 hour testing

Test section (RPV model)

- The shape and dimension of RPV model are finally chosen.
- It was solved to make RPV model from usual carbon steel (matrix) and insert the samples of RPV steel into the matrix wall in chosen points.
- Samples of RPV steel will be equipped with thermocouples for different dept.
- Design of samples fixing in the matrix is under way.
- Both part of test sections were requested for procurement.
- Necessity of thermal insulation on the test section outer surface will be discussed.

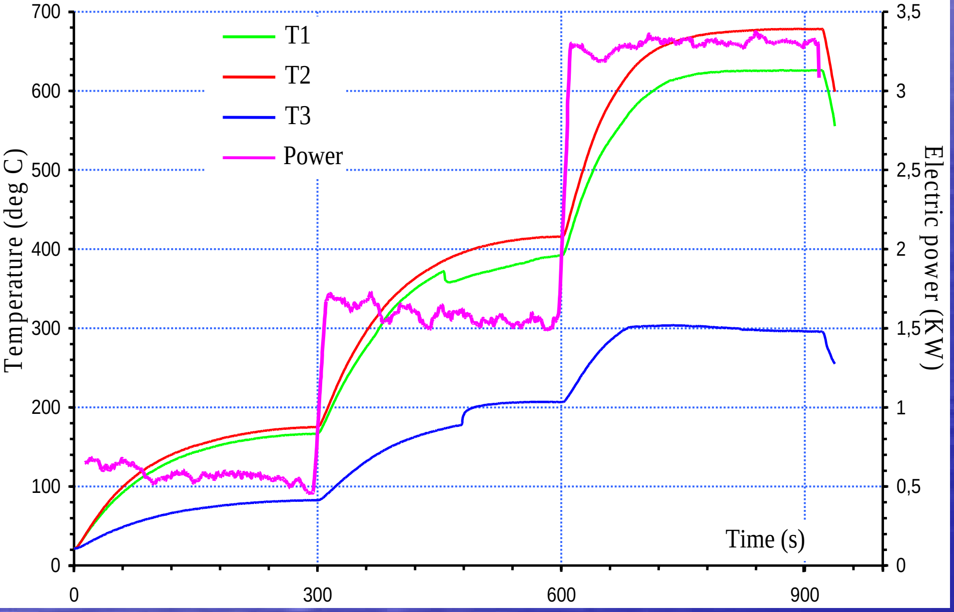
Test section (RPV model)



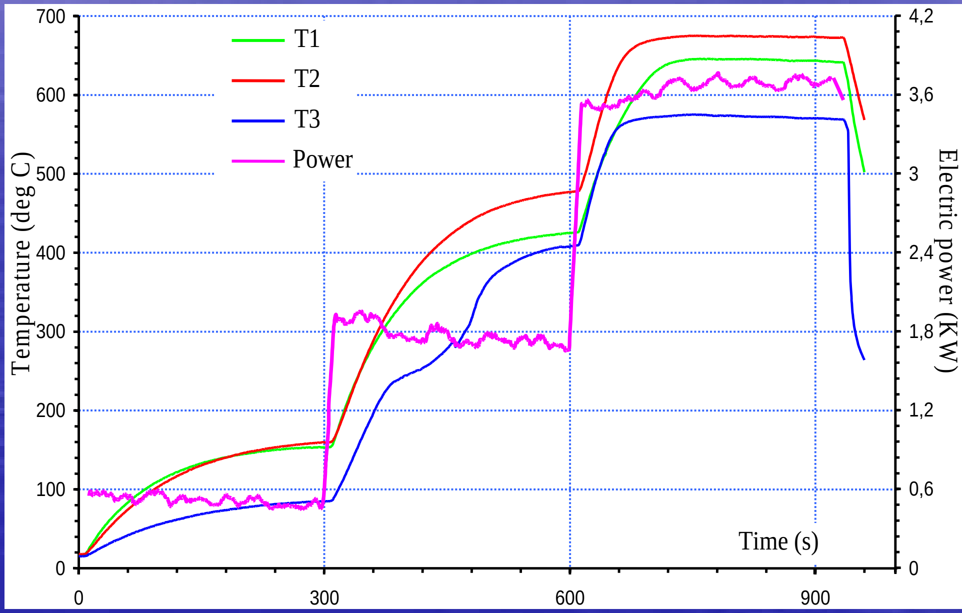


Small-scale test for estimation of thermal flux

Test section (RPV model)



Glass fabric



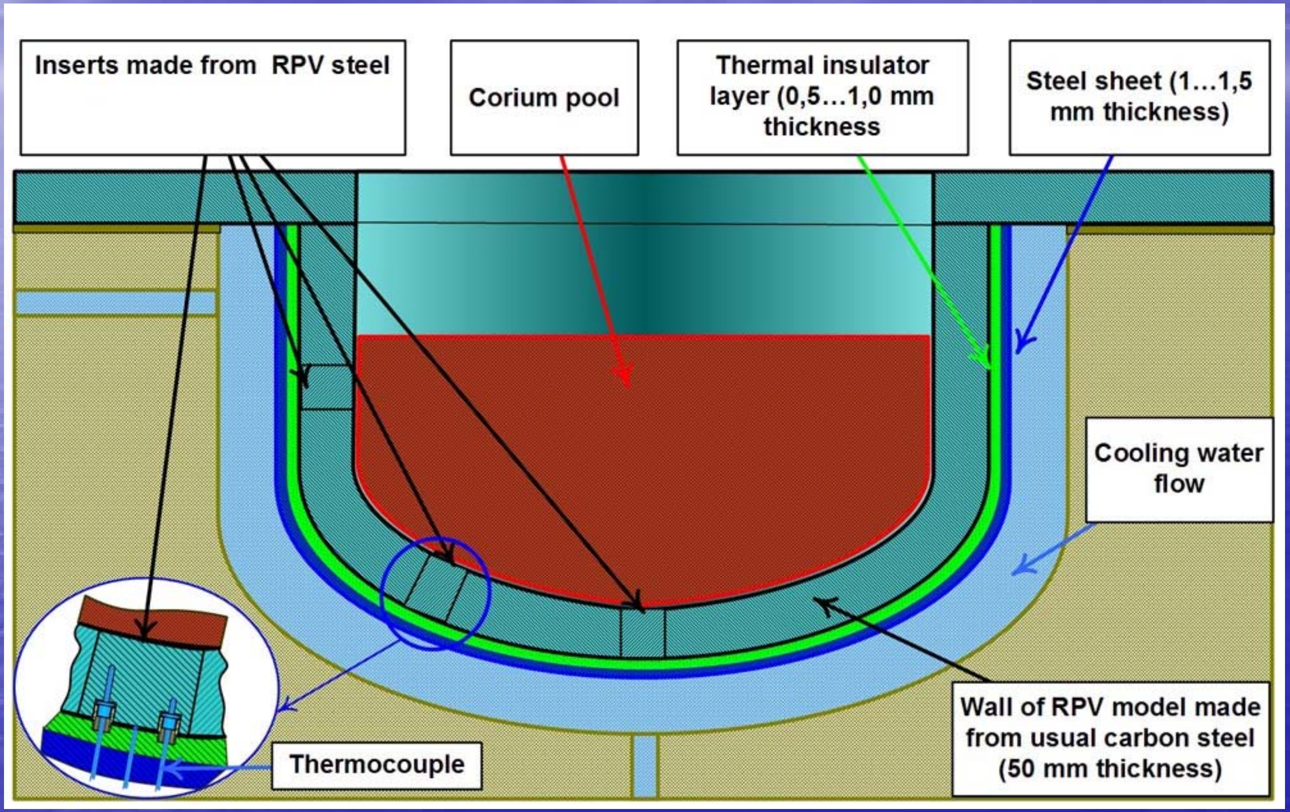
Graphite fabric

Test parameters history

Test section (RPV model)
(small-scale test parameters)

Parameter	K2	K3	K4
Open flow area of calorimeter, S_p, mm^2	486,7	486,7	486,7
Dimension of heated cylinder, $d_{in} \times d_{ex} \times h$,	40×46×100	40×46×100	40×46×100
Water flow rate, Q, liter/s	0,208	0,208	0,208
Inductor coil diameter, D, mm	95	95	95
Average water temperature, degree C	~16	~16	~16
Thermal insulation	Glass fabric	Glass fabric	Graphite fabric
Thickness of thermal insulation, mm	0,32	0,32	0,5
Maximum temperature difference (T2-T3), K	380	386	102

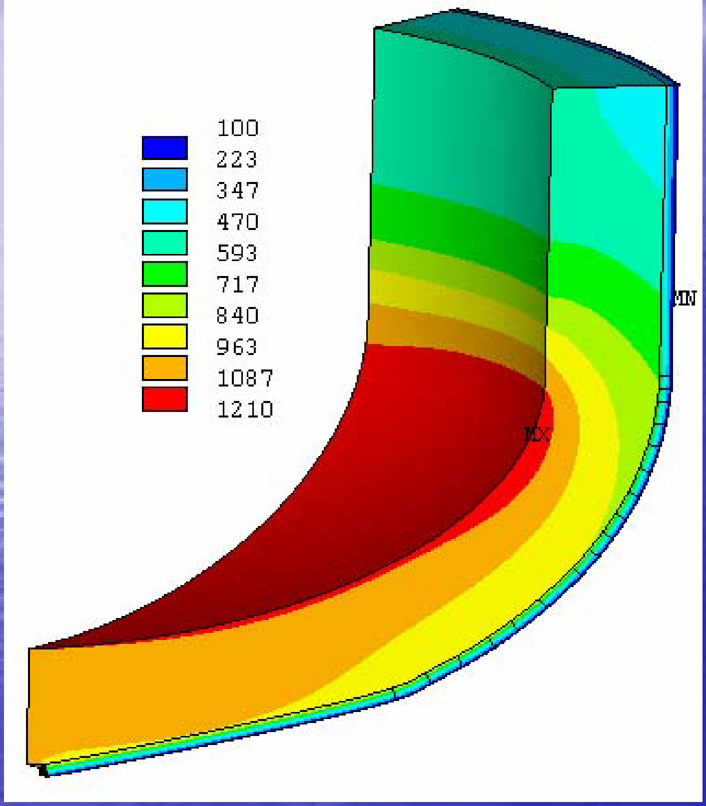
Test section (RPV model)

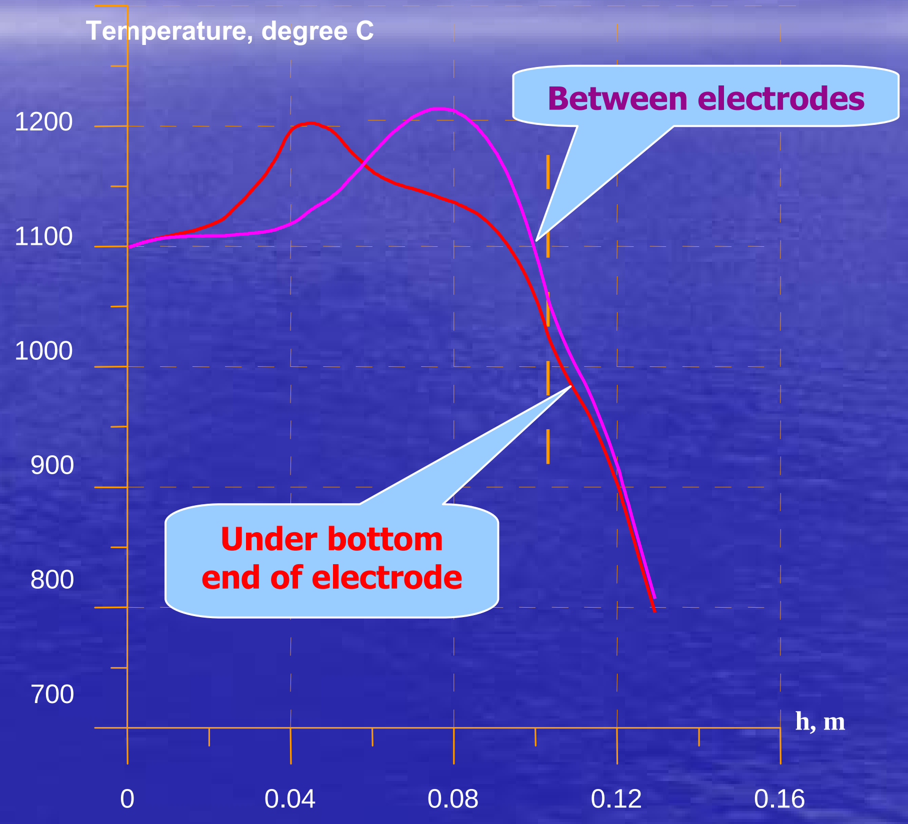


Possible design of RPV model

Test section (RPV model)

Corium pool pre-calculation using profile thermal insulation on the outer RPV model surface



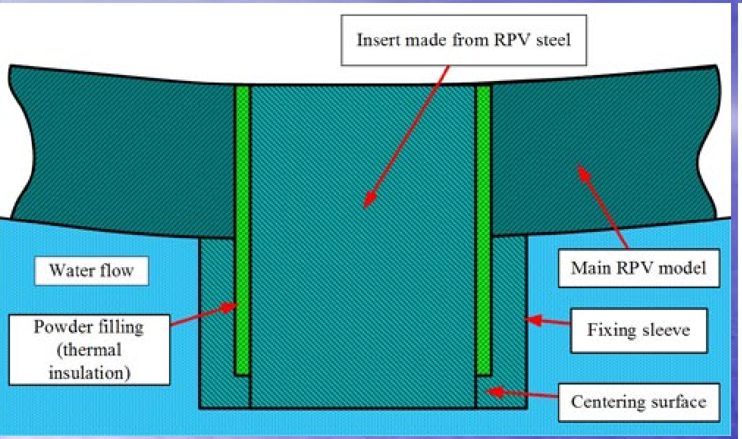


H_{CT}=45 mm

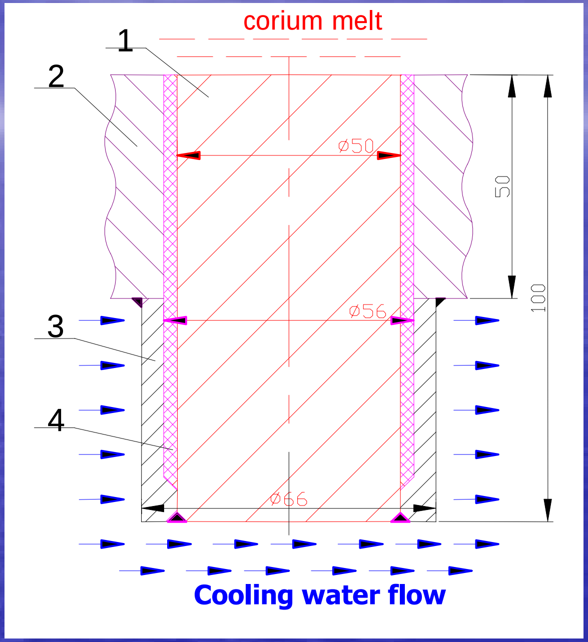
Thermal insulation λ/δ = 100 on the length from center ~ 120 mm

Thermal insulation λ/δ = 200 on the other surface

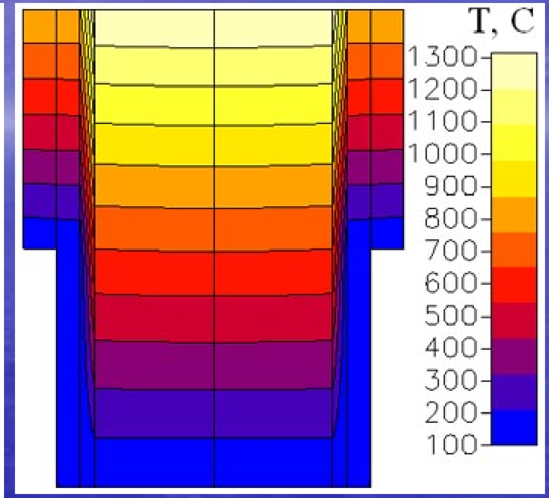
Test section (RPV model)



Scheme of design



Scheme for calculation



Temperature field in RPV insert for condition:

λ_{steel} =30 W/m ·K
λ_{ZrO2} =0.1 W/m ·K
q_{corium} =4.25E5 W/m^2
T_{water} =100 degree C

Possible design of RPV steel insert
(without thermal insulation on outer surface of RPV model)

Conclusions

- Basic works of project Working Plan are under way
- Several test in large scale facility were performed for elaboration of Zr-coating technique on the large scale crucibles (using available crucibles made from porous graphite).
- Effect of graphite porosity on molten zirconium spreading was tested in small-scale facility.
- Testing of heater for molten corium is continued and new electrodes design is developed.
- New concept of RPV model was developed. Possibility of temperature increase on the inner surface of RPV model was tested using small-scale facility.
- Pre-calculation of corium pool for new experimental section concept was performed.
- Technique development of Zr- coating application on large scale crucible and electrode nozzles is under way
- Data acquisition system improvement is performed during current tests performance