Study of corium transient behavior; Corium properties measurements

RRC “Kurchatov Institute”
NPO LUCH
IBRAE
Presented by
V. Strizhov

11th CEG-SAM, Dresden, March 7-9, 2007

Background

- Since 1994 the Russian Research Center "Kurchatov Institute" as an Operating Agent performs the OECD RASPLAV and MASCA Projects investigating the behavior of prototypic materials in the lower head
  - Develop the accident management strategy at the stage of the melt pool formation in the lower head
  - Determine the boundary conditions for the success of the strategy
  - Study material interactions and their influence on the success of the IVR concept

Outcomes from the RASPLAV/MASCA Projects

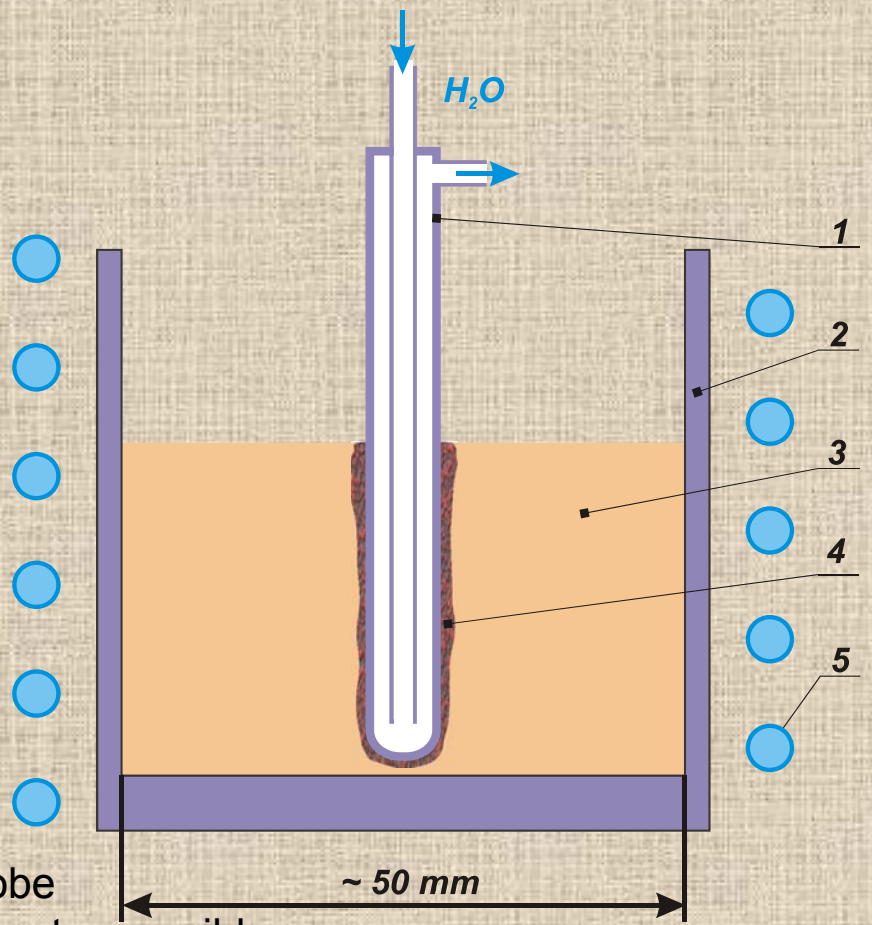
- The RASPLAV/MASCA Project results provided new insights on the behavior of the corium and structural materials and their interactions and cover PWR, VVER, BWR and CANDU parameters
- Success of the long term in-vessel retention strategy depends on the corium oxidation degree and amount of steel in the lower head
- The infrastructure and methodology was developed to conduct corium tests and measurements of corium properties and properties of metallic phase obtained in the tests as well

Open issues

- Understanding of the melt pool transient behavior is one of the issues determining the success of the in-vessel retention strategy
  - Stability of layered configuration
  - Debris behavior and meltpool formation
- Extension of the material properties database
  - Molten ZrO_2 properties
  - Corium properties

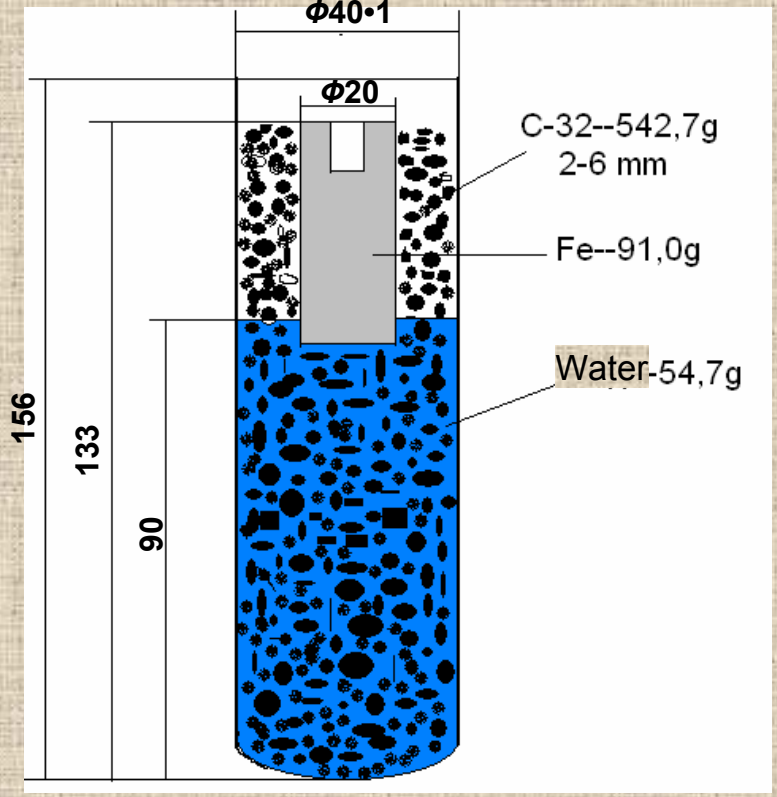
Proposal 1: Crust growth kinetics

- The objective: study of crust transient behavior
- Experimental studies in conjunction with the theoretical analysis proposed by M.Veshchunov
  - Isothermal conditions
  - Cooled tube
  - Variable parameters: corium composition, exposure time

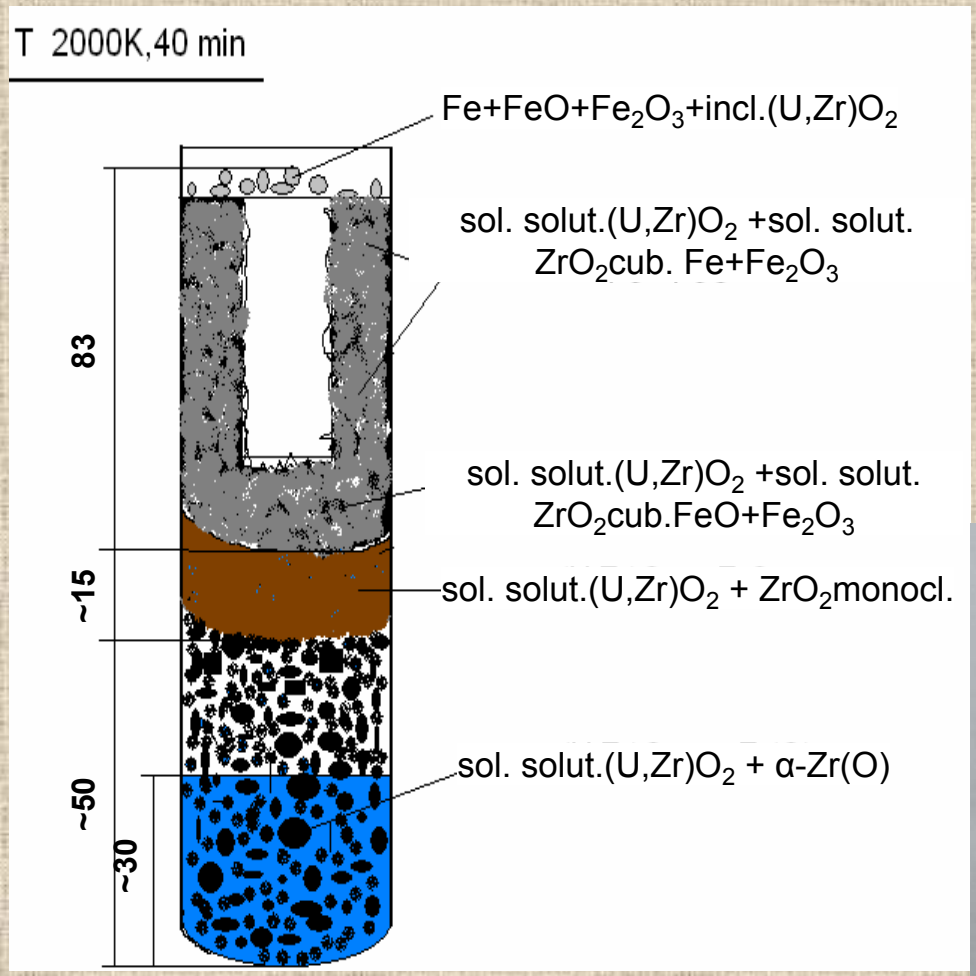


1-probe
2-tungsten crucible
3-corium (C-32, C-50, C-70, C-100) melt
4-crust
5-inductor

C-32+Fe+H_2O



C-32+Fe+H_2O T~2000K, 40min



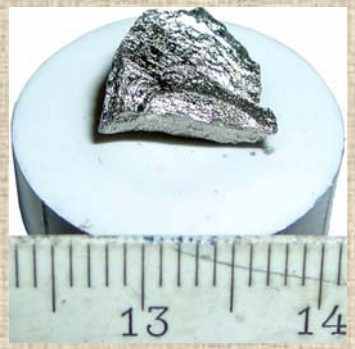
Proposal 2: Study of the debris formation and structure

- The goal of the project is to study formation and behavior of the debris in the vessel
- Test conditions:
  - Continuous oxidation by steam
  - Temperature gradients
  - scale
- Varying parameters:
  - Scale of the tests
  - Amount of steel
  - Corium composition

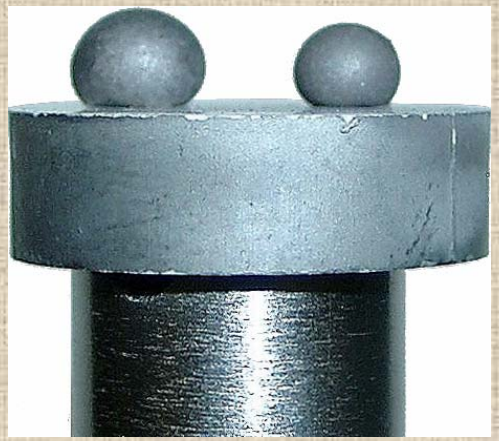
Selection of the Undercoat Material and Development of the Manufacture Technology

UO_2 T_{melt} = 2850°C
ZrO_2 + 20% Y_2O_3 T_{melt} ~ 2600°C
} Interaction at T = 1600 – 1800°C

Y_2O_3 - T_{melt} ~ 2415°C – Undercoat of Y_2O_3 did not practically interact within 10 minutes up to the temperature of 2000°C.



Droplet Δm <10^{-2}wt%

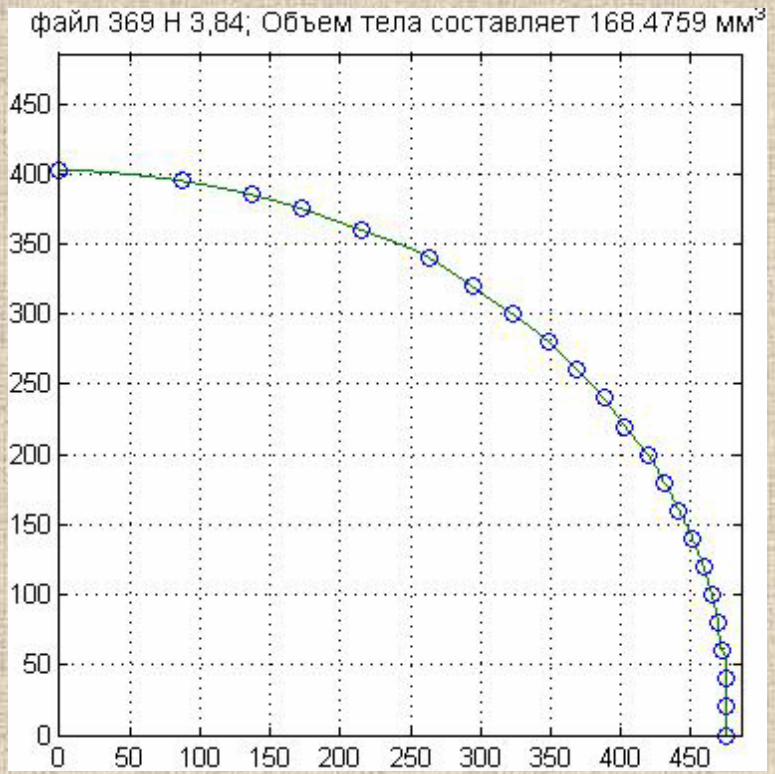


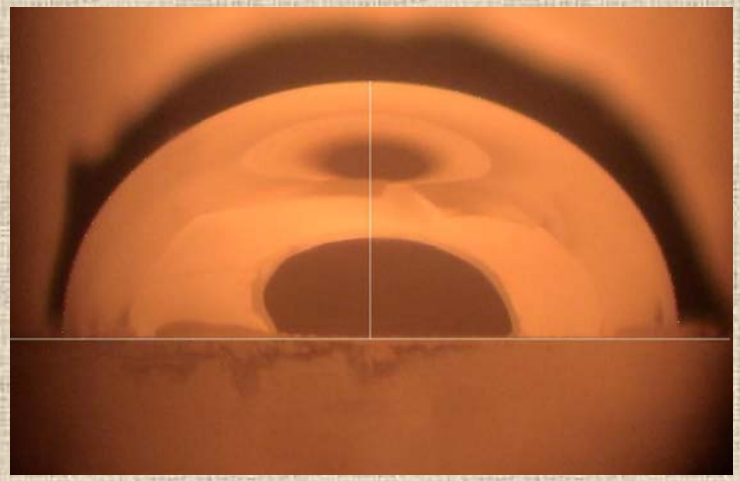
Items densities = 90 – 95 %.

Iron Density

(C-0.02; Si-0.023; Mn-0.015; S-0.02 mass%; Fe-rest)

T=1650°C
Undercoat: Al_2O_3
M_{iron}=1.1652 g; 1.1808 g; 1.2254 g.



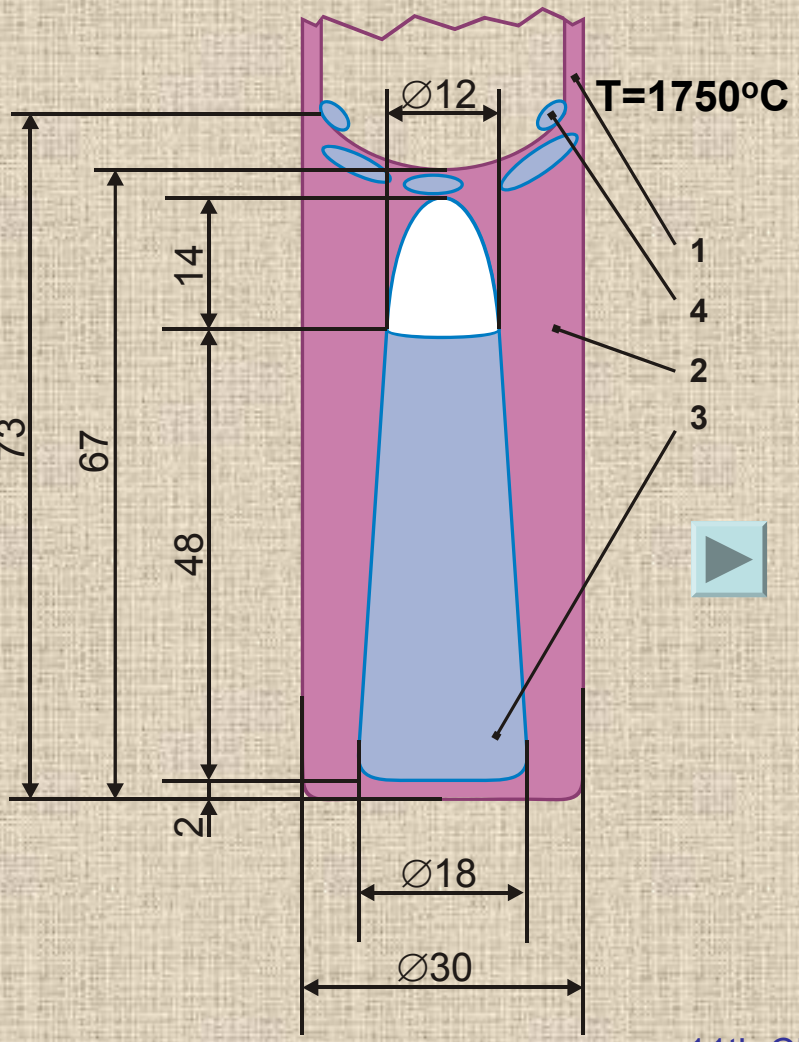


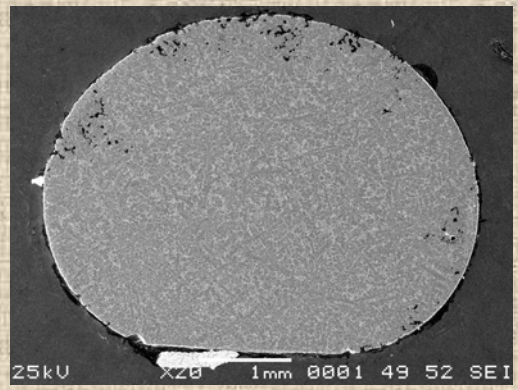
#	Mass, g	Droplet height, mm	Droplet volume, mm^3	Density, g/cm^3.
1	1.1652	3.84	168.4759	6.916
2	1.1808	4.00	169.3137	6.974
3	1.2254	4.08	175.253	6.992

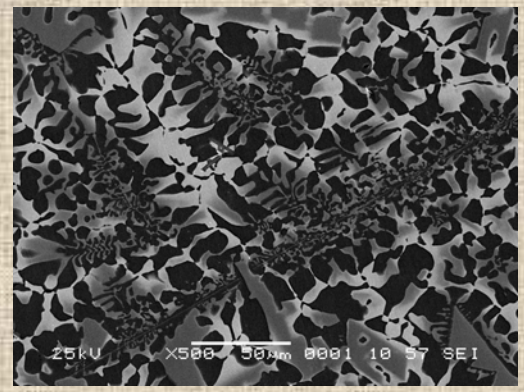
ρ_{aver}=6.961 g/cm^3
ρ_{ref}=7.0505-7,06•10^{-4}(t-1535°C), g/cm^3
ρ_{1650}=6.9695 g/cm^3 Δ=0.12%

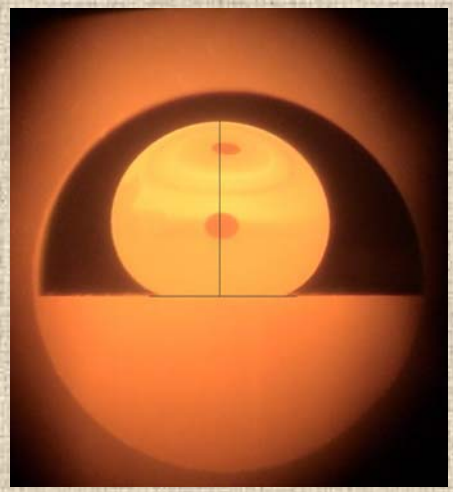
Metallic Alloy Density

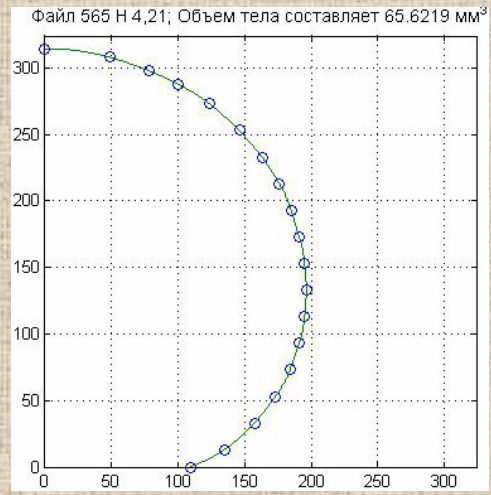
Metallic phase density 8.65 g/cm^3











The results are available for participants of the MASCA2 Project

Proposal 3: Properties measurements

- The goal of the project is to study properties of molten corium components and coria
  - Density
  - Surface tension
- The following species to be studied:
  - ZrO_2
  - Corium of different compositions