

Background

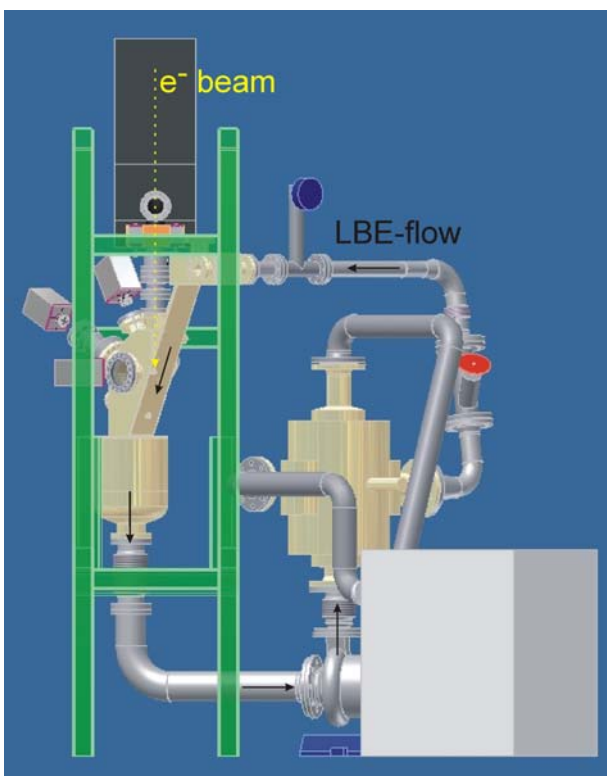
Within the European 6th framework programme EUROTRANS the experimental Accelerator Driven System XT-ADS is being developed using the MYRRHA DRAFT-2 as starting point. The aim for the XT-ADS is to demonstrate the feasibility of the ADS concept at reasonable power levels and to serve as a high performance, multi-purpose experimental irradiation device. The design includes a high-power windowless spallation target operating with liquid Lead-Bismuth eutectic (LBE). One crucial point in the development of the spallation target is the demonstration of the safe and stable operation of the free LBE surface under irradiation of a high-power proton beam. As a first step in this programme, WEBExplr (Windowless Electron Beam Experimental Irradiation) was set up.

Objectives

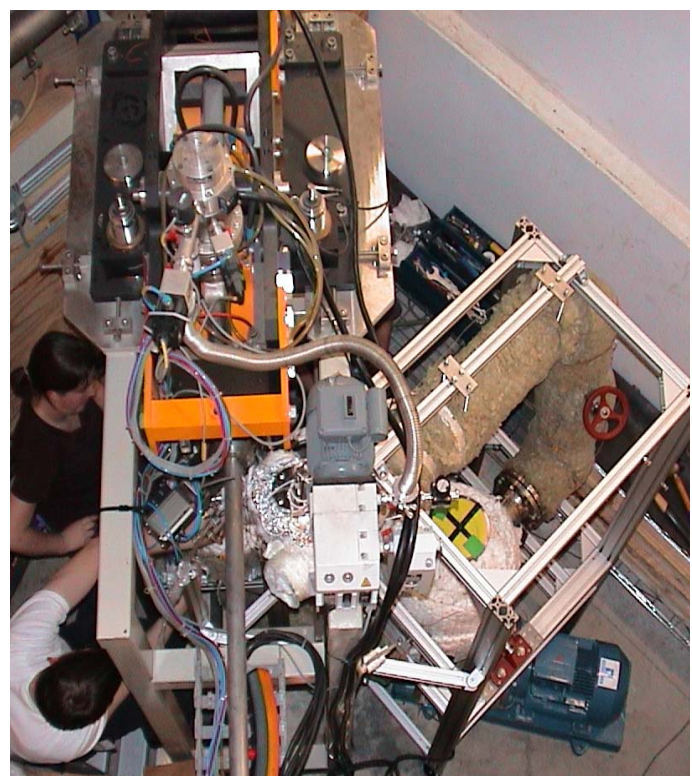
The main objective of WEBExplr is to investigate the influence of surface heating caused by the particle beam on the LBE flow in a geometry that forms a realistic representation of the spallation target. In particular, during irradiation, the effects of flow instabilities, shock waves, droplet ejection and excessive metal evaporation are monitored.

Principal results

In the past year, an LBE loop was constructed for the special purpose of WEBExplr. The central part of the loop is the interaction chamber in which a free surface flow is created that forms a full-scale representation of a sector of the funnel shaped spallation target free surface of the MYRRHA/XT-ADS. This approach combines the requirements of having an experiment with realistic flow geometry on the one hand and sufficient access to the free LBE surface for diagnostics and flow characterisation on the other hand. In the loop, the essential geometrical features of the target flow i.e. a velocity of up to 2.5 m/s, confinement in all directions except for the free surface and a 26° inclination of the free surface with the vertical direction are retained. Surface heating of the LBE flow is provided by irradiation with a 7.5 MeV electron beam generated by a TT1000 rhodotron at the site of the Belgian cyclotron manufacturer Ion Beam Applications s.a. (IBA). An electron beam is chosen to avoid the experimental difficulties that arise when employing a high energy proton beam in view of materials activation and the production of radioactive isotopes. Because of the

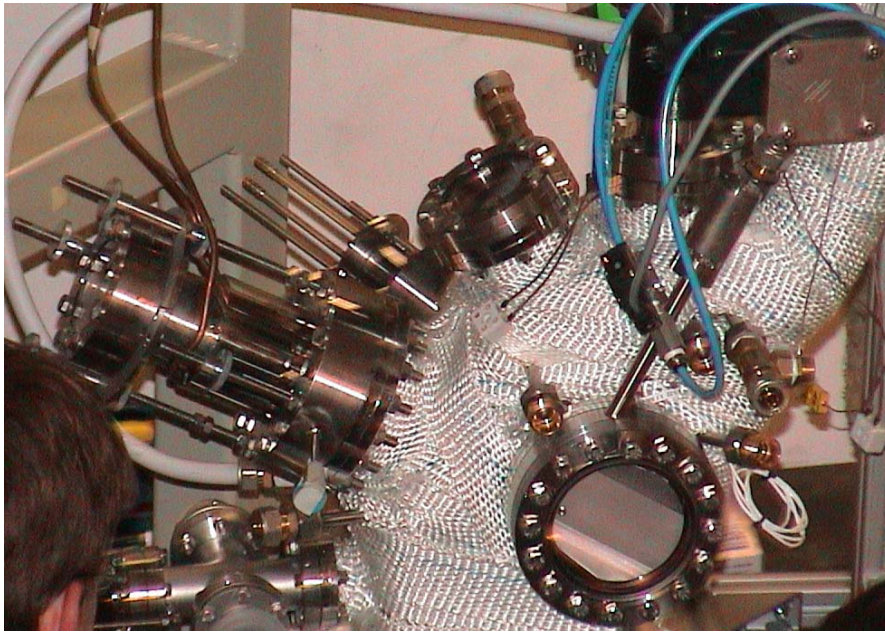


Schematic view of the WEBExplr LBE loop



WEBExplr being installed at the rhodotron at IBA

relatively low electron energy and the high stopping power of the LBE, the penetration depth of the electron beam is only about 2.5 mm thus ensuring clean surface heating. Total beam power levels of up to 20 kW are used, corresponding to a surface heating level that exceeds the nominal surface heating by the proton beam in MYRRHA/XT-ADS by a factor ten. In order to circulate the LBE through the loop, a magnetically coupled high temperature impeller pump, capable of producing a pressure head of 5 bars at a flow rate of 10l/s is installed. Cooling of the loop is ensured by a 20 kW LBE/thermal-oil heat-exchanger that is coupled to a secondary oil/water cooling circuit. In addition, water cooling is installed on specific zones of the interaction chamber to prevent excessive heating of the chamber walls due to scattered electrons and gammas. During irradiation, the LBE flow at the interaction point is monitored using both a visual and an infrared camera thus providing information on the flow stability, droplet ejection and temperature distribution on the LBE surface. In addition, fast response pressure transducers are placed underneath the flow to detect possible shockwaves. Downstream of the beam spot, the temperature distribution of the LBE flow is measured with an array of thermocouples that are distributed over the width of the irradiated area. Finally, an unshielded hot cathode vacuum gauge is used to measure possible pressure surges caused by LBE evaporation.



WEBExplr LBE loop : interaction chamber

Future work

Full irradiation experiments of the WEBExplr loop will take place in February 2007. After data analyses the results of the experiment will be used as input for the design and the safety assessment of the MYRRHA/XT-ADS spallation target. The WEBExplr LBE loop will be employed in LBE flow experiments for further optimisation of the spallation target nozzle design.

Main contact person

Paul Schuurmans, paul.schuurmans@sckcen.be

Main reference

P. Schuurmans, M; Dierckx, J. Heyse, K. Rosseel, K. Van Tichelen, A. Guertin, A. Cadiou, J.M. Buhour, M. Abs, D. Vandeplassche, "WEBExplr: Windowless Electron Beam Experimental Irradiation", Conference proceedings "Utilisation and Reliability of High Power Proton Accelerators", Mol, Belgium, 6-9 May 2007