The new laboratory for development of advanced nuclear fuels at Chalmers University of Technology, Sweden

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Abstract

In 2009 the Swedish Research Council granted funding for the Genius project. This project is a collaboration between three Swedish universities. It comprises three work packages namely: i) fuels; ii) materials; iii) instrumentation, safety and security.

The goal of the fuel work package is to build up a national laboratory where advanced Generation IV fuels containing plutonium, americium and curium can be developed, fabricated, analysed and tested. In order to model the in-pile behaviour of these materials thermodynamic and thermo-physical properties will be measured. The fuels considered are in particular solid solution nitride fuels and composite oxide fuels.

This paper briefly describes the laboratory that is now under construction at Chalmers University of Technology.

Introduction

The world's increasing energy demand together with the challenge of decreasing emissions of greenhouse gases provides new opportunities for nuclear energy to play a role in the transition towards sustainable energy system solutions. At present (1 October 2010) 441 nuclear power plants are in operation and 60 are under construction [1]. Sweden generates more nuclear electricity than any other country in the world, at present 8.02 TWh per 1 million inhabitants [2] (in the United States the corresponding figure is 2.74 TWh). Its presently 10 nuclear power reactors, which were connected to the grid between 1972 and 1986, are currently being upgraded with up to 21% increased power production. In January 2009 the almost 30-year-old ban on new nuclear power was lifted, and from 1 January 2010, it will be allowed again to build new nuclear power plants to replace the older ones. All types of nuclear power related research is allowed since the anti-nuclear laws from the early 1980s were cancelled in 2006.

The nuclear renaissance in Sweden in combination with the ageing reactor fleet that has to be replaced within the next 15 to 30 years (the reactors are between 25 to 38 years old) has created an interest in the reactor systems to come. Generation IV systems are of great interest since they also provide a possibility to burn all actinides and to increase the fuel utilisation tremendously.

In 2009 the Swedish Research Council granted funding for the Genius project (Generation IV Research in Universities of Sweden). This project is a collaboration between Chalmers University of Technology in Gothenburg, the Royal Institute of Technology (KTH) in Stockholm and the University of Uppsala. The Genius project comprises three work packages namely: *i)* fuels; *ii)* materials; *iii)* instrumentation, safety and security.

The goal of the fuel work package is to build up a national laboratory, SWANFUEL (Swedish Advanced Nuclear Fuel Laboratory), where advanced Generation IV fuels can be developed, fabricated, analysed and tested. In order to model the in-pile behaviour of these materials thermodynamic and thermo-physical properties will be measured. The fuels considered are in particular solid solution nitride fuels and composite oxide fuels.

The new facility at Chalmers University of Technology

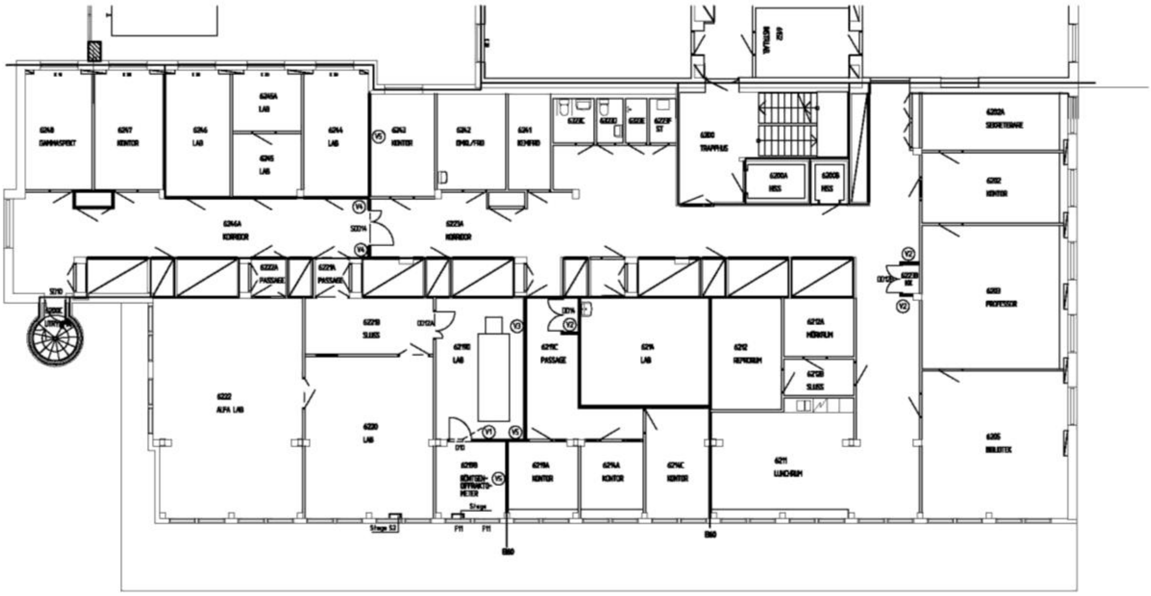
The work concerning advanced nuclear fuels will take place in the existing uranium fuel fabrication laboratory at KTH [3] and a new facility for plutonium and americium bearing fuels at Chalmers.

The new laboratory is an extension of Chalmers alpha laboratory. This unique facility, which is one of only three university facilities in Europe, already has permits to handle gram amounts of plutonium and macro amounts of americium. The new work will require an extension of these permits; this extension will, however, be rather modest.

As can be seen in Figure 1 the new laboratory has been created by adding a room to the existing alpha-lab. As a consequence it is possible to use the existing infrastructure. The new lab is connected to the existing alpha-lab airlock and ventilation system, and it will also use the existing hand/foot monitoring system for those who leave it. The security of the alpha-lab area (including the new fuel laboratory) will be strengthened, *e.g.* with new alarm systems against intruders, reinforced walls, security glass windows and a very limited access. Like the rest of the alpha laboratory the fuel laboratory will have a lower air pressure than the airlock (which in turn has a lower pressure than the corridor).

For efficient radiation protection the new laboratory will have, in addition to dose meters and contamination meters, an air monitoring system as well as a neutron monitoring system.

Figure 1: The SWANFUEL facility at Chalmers; the laboratory is in the lower left part of the drawing



The equipment will include glove boxes, a mill for grinding and mixing materials, a press, a sintering oven and other equipment. The glove boxes will probably be shielded to allow work with large amounts of americium and possibly macro amounts of curium. The laboratory will also be equipped with an X-ray diffractometer for characterisation of samples.

Building work started in September 2010 and it will be finished during November. The laboratory is scheduled to be operative during the first half of 2011.

Planned research

Today a standard nuclear fuel contains oxides of uranium and/or plutonium. Such fuels may be applied in Generation IV reactors but they are limited in terms of breeding performance and they have poor thermophysical properties. Therefore advanced fuels are under development, based on composite fuels, nitrides, carbides and metal alloys. In the new laboratory nitride fuels containing plutonium and/or americium (and possibly curium) will be a major research field. Nitride fuels have advantages in terms of higher fissile density and higher thermal conductivity. They also have a better solubility in nitric acid which will make recycling easier; the recycling of fissible materials is a key issue in all Generation IV systems. Nitride fuels are, however, complicated to fabricate and they show high-temperature stability problems. Thus there is a lot of work to do before such fuels can replace the fuels of today.

The fabrication procedure will also be an issue to investigate in detail. Uranium nitrides can be produced by sintering of powders. This is not necessarily the best method if working with alpha-emitters like plutonium and americium. Possibly a sol-gel process where the components are in liquid solution will be preferable because of less risk of proliferation of radioactive dust.

The intention is to perform part of the research in international collaboration.

Acknowledgements

The authors want to thank the Swedish Science Council for financial support.

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