OVERVIEW OF ALLEGRO PROJECT

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1. Objective and mission

An ALLEGRO demonstrator is an essential step to establish confidence in the innovative Gas Cooled Fast Reactor (GFR)technology. The proposed demonstrator, would be the first ever gas cooled fast reactor to be constructed. The objectives of ALLEGRO are to demonstrate the viability and to qualify specific GFR technologies such as fuel, the fuel elements, helium-related technologies and specific safety systems. In particular, the decay heat removal function, together with demonstration that these features can be integrated successfully into a representative system [1] is of great interest.

The attractive GFR concept aims to combine the benefits of fast spectrum and high output temperature (up to 850 °C), using helium as a coolant.

The high coolant temperature allows targeting high energy conversion efficiency (43-48 %) and opens the possibilities for new application of nuclear energy, such as heat intensive processes (metallurgy, hydrogen or synthetic hydrocarbon fuel production…). The GFR concept aims to provide these new potentialities by affording a sustainable energy supply in the long term.

In comparison with sodium, gas coolants have the following advantages for fast reactor applications:

- Chemical compatibility with water, obviating the need of an intermediate coolant loop, and generally good chemical compatibility with structural materials.
- Negligible activation of coolant.
- Optical transparent, simplifying fuel shuffling operations and inspection.
- Gas coolants cannot change phase in the core, reducing the potential of reactivity swings under accidental conditions.
- Reduction of the positive void effect typically associated with sodium
- Gas coolants generally allow a harder neutron spectrum, which increases the breeding potential of the reactor.

2. Review of the design by CEA

The CEA design of ALLEGRO is characterized by two main loops and thermal power 75 MW_{th}[1]. The secondary circuit with pressurized water connected to the main heat exchangers has been chosen to remove heat from the primary system. This option permits to rely on basic helium-water heat exchanger technology and materials, even in the case of high outlet temperature typical for the demonstration core. Heat is finally transferred by air coolers from the secondary circuit to the atmosphere, as the ultimate heat sink. The flow diagram of the main cooling system is presented in Fig. 1. This follow diagram represents parameters for starting MOX core. There is assumed another core as well utilizing the advanced fuel rod cladding material and core outlet temperature reaching 850 °C.

2.1 ALLEGRO core

During its life, the ALLEGRO demonstrator will have different cores. A starting core or "MOX core" with existing or close to existing technology (MOX pin type sub-assembly with metallic cladding) will be used. The ALLEGRO MOX core relies on existing technologies, namely MOX fuel pellets, 15-15Ti steel cladding and wire spaced pin type bundles already developed for Sodium Fast Reactors. Core outlet temperature for MOX fuel will be 530 °C. The MOX core contains 81 MOX assemblies and 6 experimental assemblies for the new ceramic fuel, see Fig. 2.

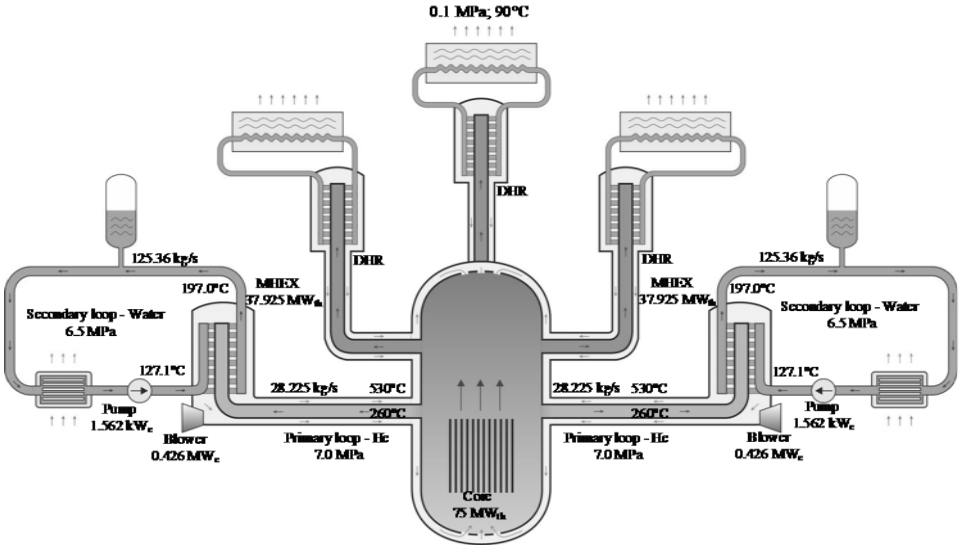

Fig. 1: *ALLEGRO concept by CEA: Scheme of the primary and secondary circuits + DHR.*

The second "ceramic" core (mixed U-Pu carbide pellets inside SiC_f/SiC claddings) will serve for testing and qualifying the new fuel design and for testing the overall design of the gas cooled fast reactor at very high temperature conditions (850 °C). A ceramic cladding material will be better from the safety point of view in comparison with MOX, as it melts at higher temperatures.

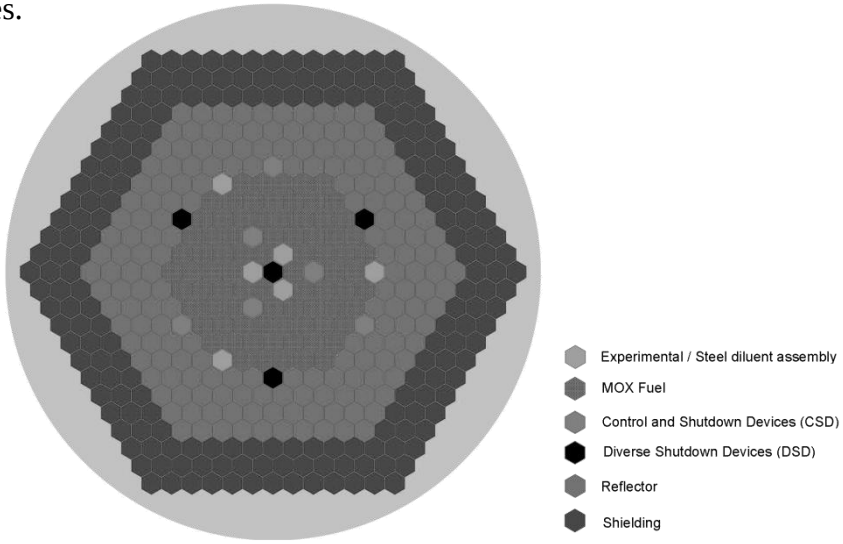

Fig. 2: *ALLEGRO Core [2]*.

3. VUJE's activities in Project ALLEGRO

This chapter offers short description of the projects where VUJE, a.s. participates and solves important ALLEGRO questions.

3.1 Establishment of V4G4 Centre of Excellence

Four main organizations carry the ALLEGRO Project on the basis of a Memorandum of Understanding from 2010.

The nuclear research institutes of the Visegrád-4 (V4) region (ÚJV Řež,a.s., Czech Republic, MTA EK, Budapest, Hungary, NCBJ, Świerk, Poland and VUJE, a.s., Slovakia) agreed to establish the "V4G4 Centre of Excellence" for performing joint research, development and innovation in the field of Generation-4 (G4) nuclear reactors and managing the Project ALLEGRO. The new association "V4G4 Centre of Excellence" was introduced to the public at the Hungarian Academy of Sciences on 18.July, 2013 [4].

The support of the current fleet and more particularly the extension of their life operation with the highest level of safety remains the first priority for nuclear research organizations like the 4 founding members of the V4G4 Centre of Excellence. To prepare future their main objective is the development of the 4^{th} generation of nuclear reactors based on fast neutrons. This new generation of nuclear reactors will meet the objective of a sustainable nuclear energy, based on the highest safety standards.

V4G4 Center of Excellence aims at:

- Investigating crucial aspects, in particular regarding safety, and generating experimental results for the development of Generation 4 nuclear reactors, especially for the innovative concept GFR (Gas Cooled Fast Reactors) for which a demonstrator, ALLEGRO, will be built and operate in the V4 region in the 2020's;
- Promoting and popularizing the potential, perspectives, technical, political and environmental issues related to Generation 4 nuclear reactors;
- Contributing to the preservation of nuclear qualifications by involving young scientists and engineers into its challenging research and development activities,
- Facilitating the integration of nuclear research in Central Europe.

In the next decades the ALLEGRO project and the V4G4 Centre of Excellence will be a cohesion force for leading edge research and technology in this region and will provide an excellent opportunity for industries of high added value.

3.2 ALLIANCE Project

The official full title of the project is "Preparation of ALLegro - Implementing Advanced Nuclear Fuel Cycle in Central Europe" [3]. The ALLIANCE project focuses on the preparatory phase for developing the ALLEGRO demonstrator. This is based on the Gas Fast Reactor concept, one of the 2 alternative systems under the SET-Plan's European Sustainable Nuclear Industrial Initiative (ESNII), expected to be built in Central Europe. ALLIANCE covers number of preliminary studies on fuel management, R&D roadmap & infrastructures needs, and siting, as well as the licensing roadmap, preliminary design and safety analysis. ALLIANCE integrates experience and knowledge gained from the past or ongoing related initiatives.

Arguments on why GFR technology could be accepted in Europe as a complementary option of SFR will be clearly stated. Furthermore it maps and highlights national or regional initiatives supporting the development of this technology and lists countries interested in the hosting of the ALLEGRO demonstrator on its territory. The conditions for the site selection should be defined within this project.

In addition the project specification on licensing and construction period was suggested. For the R&D activities as well as for the operational and decommissioning phases specifications should be elaborated. These specifications would cover the licensing roadmap, financing and project organisation setup. According to the latest concept, a common Centre of Excellence was created in Central Europe for GFR studies. The creation of the Centre is the first step towards integration of fuel and reactor safety research in the region.

Nine institutions collaborate at ALLIANCE project: MTA EK project leader (Hungaria), ÚJV Řež, a.s. (Czech Republic), VUJE, a.s. (Slovakia), CEA (France), NCBJ (Poland), INBK (Germany), IRSN (France), BME (Hungary), Centrum výzkumu Řež, s.r.o.(Czech Republic). Duration of the project is 36 months.

3.3 VINCO Project

The official full title of the project is “Visegrad Initiative for Nuclear Cooperation”. After a common expression of willingness to cooperate and legal establishment of V4G4 Centre of Excellence Association, VINCO project represents the next stage of capacity building in nuclear technologies in Central European countries [5]. Participating countries defined already their specializations: helium technology in Czech Republic, design and safety analyses in Slovakia, fuel studies in Hungary and material research in Poland. Having such expertise, the joint development of Gen IV nuclear technologies with the special emphasis on gas-cooled reactors is fully possible.Thus, the main objectives of the regional VINCO project are: development of the principles of cooperation and rules of access to existing and planned infrastructure, identification of the specific objectives of the R&D activities in the cooperating countries, description and analysis of the existing research, training and educational equipment and capabilities, determination of the investment priorities in cooperating countries and setting up of joint research, educational and training projects. It is expected that the joint activities will result in coordination of actions allowing obtaininga financing from the Structural Funds available for the Visegrad countries. These funds would allow for a huge increase of mass and modernization of the research potential in the region.

3.4 ESNII+ Project

European Sustainable Nuclear Industrial Initiative (ESNII) addresses the need for demonstration of Gen-IV Fast Neutron Reactor technologies, together with the support to research infrastructures, fuel facilities and R&D work. As indicated in its Strategic Research & Innovation Agenda, SNETP has prioritised the different Gen-IV systems and is proposing to develop the following projects [2]:

- The sodium-cooled fast neutron reactor technology (the ASTRID project) as the reference solution, with the construction of a prototype around 2020 in France, which is strongly supporting this technology
- As a first alternative technology, the lead-cooled fast reactor (ALFRED) with the construction of an experimental reactor to demonstrate the technology, in another European country willing to host this programme, and supported by a lead-bismuth irradiation facility project in Belgium (MYRRHA)
- As a second alternative technology, the gas-cooled fast reactor (ALLEGRO), also requiring the construction of technology demonstrator in a European country

The ESNII+ project aims to define strategic orientations for the Horizon 2020 period, with a vision to 2050. To achieve the objectives of ESNII, the project will coordinate and support the preparatory phase of legal, administrative, financial and governance structuration, and ensure the review of the different advanced reactor solutions.

The work package 6 is concentrated on ALLEGRO MOX core specification. All of the participants willdevelop the ALLEGRO core models with their static neutronic codes and nuclear libraries, andmake calculations of the main performance and safety parameters: Doppler constant, reactivitycoefficients, control rod worths, etc. To facilitate the comparison of the results, at the beginning ofthe work, MTA EK on behalf of the ALLEGRO Consortium will prepare and distribute the unifiedtemplate, containing the list of the required parameters to be provided by each participant.

3.5 ALLEGRO Roadmap

This document, presents the updated Roadmap of the European gas cooled demonstration reactor ALLEGRO project following the recommendation of the V4G4 Steering Committee, namely [6]:

- Startup core with reduced thermal power to face the safety limits of the stainless steel cladding of the initial oxide fuel.

- The potential use of an enriched Uranium fuel instead of MOX fuel to facilitate the procurement

The Roadmap includes a detailed technical work plan and the related R&D of the V4G4 organizations, VUJE, a.s. (Slovakia), ÚJVŘež, a.s. (Czech Republic), MTA EK (Hungary) and NCBJ (Poland).

The main phases of the whole Project are: 1. Definition of the basic safety and performance goals; 2. Pre-conceptual design; 3. Conceptual design; 4. Basic Design; 5. Detailed Design; 6. Siting and Licensing; 7. Construction; 8. Operation.

3.6 ALLEGRO Research Centre in Slovakia

On 9. September, 2014 was a starting point of the ALLEGRO Research Centre Project in Slovakia[7]. In that time the contract between Ministry of Education, Science, Research and Sport of the Slovak Republic (Ministry of Education) and Slovak Academy of Sciences was signed. Project is financed from EC Structural Funds. The project consists of three workpackages (WP):WP 1 - Establishment and initiation of the ALLEGRO Research Centre. The aim of WP 1 is the development of specialised places of work and laboratories, rooms for employees and technology transfer and includes 3 tasks: 1. Establishment of the ALLEGRO Research Centre with specialised laboratories and cutting-edge infrastructure; 2. Defining long-term strategy plan of the Research centre development; 3. Procurement and pilot operation of necessary research infrastructure

WP 2 - Applied research and development in the area of new materials and technologies. Thisworkpackage is touching the realisation of cutting-edge research and development in the area of new materials and technologies, preparation, testing and diagnostics of prototypes. WP 2 includes 6 tasks. Task 1 is fixed on adaptation and validation of neutronic and thermal-hydraulic computer codes for ALLEGRO reactor. Further workpackages are focused on material research, equipment research, diagnostics systems, etc.

WP3 - Establishment of technology transfer platform.The last workpackage goal is to establish a contact point for communication with entrepreneurial sector in frame of the Office for technology transfer; establish of incubator, identification of spin-offs and programme for support of technology transfer and mobilisation of innovations. Slovak Academy of Sciences put out a public procurement for „Contractual Research„to the tender. VUJE, a.s. won this bid with two points: A - *Research of the safety concept and systems design of the 4th generation ALLEGRO reactor;* B - *Conditions of the proposed design solution, organisational and technical provisions for ALLEGRO construction, selection and evaluation of the site for ALLEGRO construction*.

End of the project is set to 31. August, 2015.

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