New frontiers for the Nuclear Safety Analysis and TSO's challenges

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Abstract. Nuclear safety is one of the most important issues for the nuclear industry which considers that promoting high level of safety will ensure sustainability and induce economic performance. Enhancing safety passes through the development of validated tools, models and systems in order to demonstrate the safe operation of the plants during all stage of life. In the other hand, the licensing of any nuclear installation by the state regulatory bodies also passes through the assessment of the installation performance under several scenarios and hypothesis. This is a main purpose of TSOs attached to regulatory bodies. This task is generally made possible by the continuous development and assessment of tools and models and by an effective share of experience between all the partners in the nuclear industry. However, if this was made possible by the nuclear power industry because of the necessity to gain public acceptance and to higher the confidence in this technology, the situation is obviously not the same for the research reactor safety. The research reactors, as generally considered as small installations, which impact is not so considerable in case of accident compared to the impact of a nuclear power plant accident. However, in our opinion, even that the research reactors didn't experience any severe accident they are facing to ageing situations and for this reason, one of the new challenges to deal with by TSOs should concern the revisiting the safety of research reactors by upgrading the methodology adopted used to date and to follow the methodology used in the nuclear power industry and at the end attain a standardized methodology.

1. Introduction:

After the second war, nuclear power has emerged as a profitable source of energy for the development by providing safe, clean and sustainable energy to the world; however, the expected development in the utilization of this energy has been affected after the occurrence of Three Mile Island accident in 1978 and completely reduced after the Chernobyl accident in 1986. The nuclear industry has learned lessons from the above accident and has undergone major research and development in order to ovoid these accidents to occur further and to reinforce the safety of existing installation by mitigating the effects of any accident. The safety was postponed priority 1 and one of the major fields focused on was the analysis of accidents.

To perform such an analysis, models and tools has been developed and experimental devices were settled up. The simulation tools were tested, assessed and compared to experimental data. The experiments mounted by different research institutions were shared in order to minimize the coasts and to get common understanding of the phenomena under investigation. This has also helped to enhance safety capabilities by sharing knowledge between the specialists around the world using same techniques and in same cases standardized tools. Furthermore, these sophisticated tools are always under continuous enhancement and assessment. These activities were generally supported by international organization like NEA/OCDE, IAEA, WANO and also by the industry. The capitalized results of this industry effort are used as basis by national authorities to help making adequate decision in the licensing process. The successful of the cooperation and the experience shared by the nuclear partners were also made possible because of some standardization in the design of the NPP.

In the other hand, over the fifty past years, research reactors have progressed through a variety of tasks. These have included materials research using neutron scattering and diffraction, materials characterization by activation analysis and radiography, isotope production, irradiation testing, as well as training, and service as centres of excellence in science and technology. The research reactors has played important role in the understanding of the nuclear physics and in the development of the nuclear industry. Nowadays, they continue to play an important role in the generation of neutrons for different educational and social purposes.

As a consequence of the wide spectrum of utilization of the research reactors, there exist around the world large variety of designs, wide range of powers, different modes of operation and purposes of utilization, it was no possible to standardize any more the methodology like for the nuclear power industry.

An attempt to perform standardized safety analyses for RR was proposed by the IAEA in the framework of core conversion from the use of highly enriched uranium fuel to the use of low enriched uranium fuel. In this regard, the facility operator would be required to submit an amendment to, or a revision of, the Safety Report. For this purpose, a safety-related benchmark problem was specified in order to show and compare calculation methods used in various research centers and institutions over the word. This has shown that each participating institution has developed each own methodology and proper tools. Almost all of the safety analyses have been performed using conservative computational tools.

The challenge today is to revisit the safety features of the existing research reactors using Best Estimate codes and the coupled code technique. This will allow to verify that the safety requirements still met and when necessary to introduce some amendments coming from not only the new requirements but also in order to introduce new equipments from recent advancement of new technologies. However, as the existing plants have well established licensing procedures, including well founded analysis methods, the application of new innovative analysis methods have to be thoroughly evaluated, with specific emphasis to the capabilities of producing results that in general terms might be beneficial related to the RR operations.

2. Description of the tasks

The role assigned to our group is the development, validation and utilization of computer tools for the safety analysis of research reactors. To deal with these missions, the group has adopted a graded approach beginning from the selection of appropriate tools, their adaptation to specific operating conditions and their application for cases studies. In a second major step, the group has undertaken development activities and successfully developed computer tools for the determination of reactor intrinsic parameters and the analysis of accidents and transients such as reactivity insertion accident or RIA, loss of flow accident or LOFA and loss of coolant accident or LOCA.

Several assessment and validation activities have been performed but the group was always faced to the limitation access to validation matrix. Nevertheless, the models and tools have been applied to the benchmark exercise and the results were shown to be in the same range as of other institutions.

With the sustained development in computer technology, the possibilities of code capabilities have been enlarged substantially and consequently, advanced safety evaluations and design optimizations that were not possible few years ago can now be performed since very sophisticated methods and models that needed in the past heavy financial investment are nowadays accessible with minimal financial support when the technology is available.

Furthermore, du to the evolution of the computer technology, it becomes today possible to switch to new generation of computational tools using Coupled Code Technique. This method consists in coupling advanced codes each one in specific target areas of nuclear engineering in orderto get more realistic simulations of complex phenomena and accidents in reactor cores. These new opportunities has opened new options for research in different institutions even those with limited resources and/or installations.
As a fact, for some countries such our, the challenge today consist of revisiting safety features of the existing research reactors in order to verify that the safety requirements still met and when necessary to introduce some modifications coming from not only the new safety requirements but also by introducing new equipments as a result of recent advancement of new technologies. The results of these studies are the basic output expected by regulators from the technical and scientific supports teams.

3. New Frontiers and challenges

The selection of a BE analysis instead of a conservative one depends upon a number of conditions. These include the degree of the current knowledge, the availability of computational tools, the availability of suitable nuclear research reactor data (the amount of data and the related details can be much different in the cases of best estimate or conservative analyses), or the requests from the national regulatory body.

Although the acceptability of the approach to be used for an accident analysis needs to be defined by the regulatory body, the use of totally conservative approaches (conservative models, input data and research reactor conditions) results unwarranted nowadays. Indeed, using a conservative approach in the analysis of specific scenario provides some exaggerated results and hence the safety margins deducted are large enough to cover a great number of similar cases.

Furthermore, conservative analyses are still widely used to avoid the need of developing realistic models based on experimental data, or simply to avoid the tedious task in changing the approved code and/or the approaches or procedures to get the licensing. However, the results of such analyses did not give a true simulation of a specified scenario. In fact, no indications about the actual research reactor behavior or the real margins are provided.

By contrast, the phenomena, in the case of the BE methods, are simulated as realistic as possible according to the present knowledge and the obtained safety margins reflect more closely the real ones. Nowadays, the application of Best-Estimate (BE) methods constitutes a real necessity in order to get more realistic safety margin and consequently increasing the lifetime as well as the commercial productivity of these reactors.

The challenge today is to revisit the safety features of the existing research reactors using the coupled code technique. This will allow to verify that the safety requirements still met and when necessary to introduce some amendments coming from not only the new requirements but also in order to introduce new equipments from recent advancement of new technologies.

In order to achieve the above commitments and to ensure high confidence of the results, TSO have to undertake assessment and validations activities in order to demonstrate the applicability of these new techniques to the safety analysis of research reactors. This is the first requirement or step as recommended by the safety international community and organization such IAEA, NEA and other regulatory bodies around the world.

The second one is related to the qualification of the safety analyst. The technical resources represent the heart of the technical support organization (TSO) and its role is to help make strong decision in all safety related questions of nuclear installation. However, the success in these missions is also dependent on the capabilities of an international cooperation and experience sharing between TSOs organizations acting in the same area or as a hole by regulatory bodies by participation to international forums and others. The IAEA have an important role to play as moderator actor between the partners.

The objective of this new approach is to assist in achieving and maintaining a high level of safety in research reactors application and utilization and to provide a training and qualification program for personnel as well as specialized guidance for regulatory bodies. The impact of such activity will contribute to resolve specific current safety issues and assist in making a standard methodology for the safety of research reactors like in the case of nuclear power plants.

Beyond of these technical challenges faced to by TSO, one other major question to solve is the renewal and the stability of qualified human resources; this is one of the most important challenges faced to by TSO worldwide and particularly in the majority of developing countries. Systematic training of analysts is crucial for the quality of the activities related to the TSO activities. In particular, international cooperation will help transfer competence and experience in performing safety analysis using new methodologies and approaches in order to achieve high safety operation level and to realize the global objective which the safe operation of any nuclear installation over the world.

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