Master in Nuclear Engineering

ETSEIB, UPC

# INTERNSHIP REPORT

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# 1. Introduction

In the frame of the compulsory internship of the Master in Nuclear Engineering (MNE) offered by the School of Industrial Engineers (ETSEIB) of the Universitat Politècnica de Catalunya (UPC), I have been working in Idom, a Spanish engineering and consulting company.

I joined Idom's Nuclear Services department, recommended by Lluis Batet, at the beginning of the master. During the first year, I worked there at part-time in the mornings, while I was following the different courses in the afternoons. It was my first real working experience after completing the Industrial Engineering Degree with Nuclear specialization at the ETSEIB, excluding a short internship at the Commissariat de l'Energie Atomique (CEA) for the development of my degree's final project. As the first year came out to be a very good experience and Idom offered me a good opportunity to develop my professional career, I decided to stay in the company at full-time during the second year and carry out the internship and the master's final project there.

The main objectives of the internship were to participate in the different projects that the Nuclear Services department of Idom was carrying out and to develop one of them for my master's final thesis. The final aim was to get involved in the day to day of a nuclear engineering company.

# 2. Working environment

IDOM is an independent international company that delivers professional integrated services in Engineering, Architecture and Consultancy. The company is a leader in Spain and is quickly gaining a worldwide reputation. Since its beginnings in 1957, the company has assisted over 10,000 clients, participating in over 30,000 projects across five continents.

Nowadays, Idom counts more than 2400 workers and has 34 offices spread over 16 countries, with the headquarters situated in Bilbao. The company is employee owned with 100% of the capital of IDOM distributed between staff currently working in the firm. The philosophy of Idom is to provide the best possible service to each and every client.

Responding to the evolving markets, Idom has diversified its activity to different sectors and different countries. The main areas of activity of the company are:

- Consulting & Systems,
- Industry & Energy,
- Architecture & Building,
- Infrastructure,
- Telecommunications,
- Environment,
- Advanced Analyses,
- Nuclear Services
- Turnkey Services.

These last two years, I have been working as junior engineer in Idom's Nuclear Services in the Barcelona's office. Idom Nuclear Services was founded in the late 70's and has known a very important development in the last 5 years. People are distributed in Bilbao, Madrid, Barcelona and Merebrook offices but also many are posted workers on different Spanish nuclear power plants sites (Ascó, Vandellòs, Garoña, Trillo and Almaraz).

The spectrum of activities of the business unit covers a wide range of projects from minor component or subsystems analysis to major design projects for new facilities. IDOM can offer nuclear engineering services working both as an integrated resource within the client's engineering team on site and as an external resource from the various IDOM offices. The services provided by IDOM within the nuclear business unit may be grouped into the following disciplines:

- Site Evaluation
- Planning, Technical Assistance and Safety

- Design Engineering
- Industrial Architecture
- Project Management and Construction
- Turnkey Projects
- Consulting Services

The main clients of the business unit are the Spanish NPP: Ascó, Vandellòs, S.M. Garoña, Cofrentes, Trillo and Almaraz. Also many projects are developed for ITER, the international first full-scale experimental fusion reactor that is under construction in Cadarache, France. These projects are both directly contracted with ITER Organization (IO) or through Fusion For Energy (F4E), the European domestic agency. Idom is also supplier of AREVA and Enresa among others.

In Idom, each project has a technical manager that is responsible for both the technical and the economic management of the task. The company has a very horizontal structure so everybody can be technical manager in some projects and analyst is some others. As junior engineer, I was assigned a tutor when I entered. Agustín Alemán has supervised my work and my evolution these two years and has helped me to face all the obstacles. Also the technical managers I have been working for have guided me during the internship.

I have been working as analyst in two main projects: lifetime management for Ascó and Vandellòs NPP and the generation of an ITER MELCOR model for F4E. I am now starting another project on ITER MELCOR models for F4E, this time as technical manager. I have also taken part in the development of a software for coupling MCNPX and ANSYS and in the calculation of a condenser in Ascó NPP. A part from that, I have participated in different offers and I have organized a course on nuclear energy. I am also currently helping in the internal resources management.

# 3. Internship tasks

## 3.1. Lifetime Management

The Lifetime Management is one of the most relevant tasks in Idom Nuclear Services. In 2003 Idom developed the necessary studies and evaluations for the Garoña NPP operating license extension. Since 2006, Idom has also offered technical support in various areas including planning, development, implementation and monitoring to the Ascó, Almaraz, Vandellòs II and Trillo NPPs' lifetime management plans.

The design life of currently operating nuclear power plants was normally calculated i in the region of 30 to 40 years. However, most of the plants can safely be run for decades longer than originally planned. This is advantageous both environmentally and economically, since power can continue to be generated from a plant which has already off-set its construction cost, improving profitability and maintaining the low carbon performance of nuclear power generation.

In this context, plant life management integrates economic and ageing planning to maintain performance and safety as plants age. However, care should be exercised when continuing plant operation beyond the original plant life, since structures, systems and components (SSC) may have been worn out or otherwise degraded. Ageing Management Programs (AMP) are used to monitor and counteract these changes and to guarantee safe long term operation.

I am participating in the development of Ascó I and II and Vandellòs II Lifetime Management Plans. The ageing management scheme for theses nuclear power plants answers to the CSN Safety Instruction IS-22 and is implemented according the US-NRC regulation for licence renewal (10 CFR 54, NUREG-1800 and NUREG-1801).

The main activities that are currently being carried out almost in parallel for the three units are:

- Scoping and screening for identifying the systems, structures and components (SSC) subject to ageing management,
- Definition of the complete set of ageing management programs (AMP),
- Assessment of operating experience for the identification of possible plant specific ageing mechanisms,
- Ageing management review (AMR) consisting of the identification of applicable ageing mechanisms to structures and components within the scope of the ageing management and the application of ageing management programs.

The next phase activities will be:

- Assistance to implementation of the ageing management programs by the utility's personnel
- Updating of the scope of the ageing management programs due to changes in the plant
- Monitoring of the performance of the ageing management programs
- Preparation of periodic reports on the performance of the AMPs and new operating experience.

I am part of a group of 7 analysts assigned to the ageing management review task. Our job consists of analyzing all the structures, systems and components within the scope of the ageing management, identify the ageing mechanisms that could affect them and assign them the necessary management programs to mitigate and control the ageing effects. This evaluation is compared to the NUREG-1801, the reference document used to justify that applicable ageing mechanisms are adequately managed.

I am essentially focused on mechanic systems. I have studied in depth the configuration and the operation of systems such as the Chemical and Volume Control System, the Emergency Diesel Generators System or the Gaseous Waste System. There, the typical components within the scope of the ageing management plan are tanks, heat exchangers, pumps casings, piping, valves and flexible tubes. For each one of them I have identified the material and the internal and the external environments looking in the plant reference documents. All this documentation process is not always easy and generally very time consuming due to the extension of the input data.

Knowing the material of a given component and the environment and special conditions, such as temperature or operating time, to which it is subjected, the ageing mechanisms and effects that could cause a degradation of its initially intended function can be determined. This is done using the "EPRI Tools", reference reports published by EPRI as the outcome of several research programs on ageing of structures, mechanical and electrical components.

To simplify the task and avoid having to look into the "EPRI Tools" every time, an analysis of the possible ageing mechanisms and effects for every couple of material and environment that can be found in the plant is performed and reported in the so called "Groups report". With this, around 300 made up items, specific combinations of a material, an environment and other conditions that allow identifying unequivocal ageing mechanisms and effects are created. They are called commodities. This way every component is assigned a commodity that directly determines the applicable ageing effects and justifies the non-applicable ones. This part of the task requires a good understanding of the ageing processes that affect the different materials. I am currently the responsible for the review and the correction of the commodities and their justification in front of the client.

Finally, one or several ageing management programs are applied to every ageing mechanisms and effects identified in each component. This way, the scope of every maintenance activity can be settled.

The process is completed with a comparison of the ageing effects and the ageing management programs assigned to each component with the NUREG-1801 evaluations for a generic reference plant.

## 3.2. ITER MELCOR model for the assessment of the Cryostat design

Fusion for Energy and Idom signed, a few years ago a fluid dynamics framework contract within which, task #04 is devoted to the update of the MELCOR calculations for the validation of the cryostat design. This is a thermal-hydraulic project in which I have participated as analyst. At the same time I have developed it as my master's final thesis.

ITER cryostat is a cylindrical chamber that will surround the tokamak machine and maintain the vacuum and super-cool operating conditions. The objective of this project was to develop an ITER MELCOR model to simulate the behavior of the machine in case of cryostat loss of vacuum accident (Cr LOVA), in-cryostat ingress of coolant event (Cr ICE) and helium ingress in galleries (HIG). The aim was to obtain the evolution of pressures, temperatures and heat transfer coefficients to feed the mechanical assessment of the cryostat's design.

The first step to build the model was to define a nodalization made out of heat structures, control volumes and flow lines, capable of representing the thermal-hydraulic behavior of the tokamak. The radiation heat transfer system was set externally using control functions. In parallel, a deep analysis of ITER components was carried out to obtain a complete and traceable geometrical and materials database which was subsequently used to feed the MELCOR input parameters. Special attention has been given to the cryostat structures where more precision in the results is required. Different approaches were followed to model every system according to an optimization of the documentation phase and the reproduction of the thermal-hydraulic behavior.

The initial conditions corresponding to the cooling power values and the temperatures at normal operation were determined with a steady state simulation. Then, the event sequences were defined in the input deck for every accidental scenario and the simulations were run. The evolution of pressures, temperatures and heat transfer coefficients were finally obtained, post-processed and checked to verify the coherence of the results.

The project has been carried out by 3 engineers. In particular, my tasks have been to generate the ITER geometrical information database, to contribute to the model definition and implementation and to review the accidental scenarios simulations.

## 3.3. MCNPX/ANSYS coupling

I joined Idom when the project was already quite developed. However, thanks to my experience in one of the neutronics simulations division of the CEA during the development of my degree's final project, I had the opportunity to participate in this R&D project.

The objective of this R&D project was to couple the Monte Carlo code MCNPX and the CFD code ANSYS so that they can iteratively interact with each other in a semi- or fully automated way. The development of the project was partially supported by a grant of the Spanish Center for Industrial Technological Development (CDTI, Centro para el Desarrollo Tecnológico Industrial) of the Ministry of Economy and Competitiveness and developed in collaboration with academic institutions, such as UNED-Madrid (Universidad Nacional de Educación a Distancia), UPC Barcelona (Universidad Politécnica de Cataluña) and CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) of the Ministry of Economy and Competitiveness.

The idea was to determine the physical quantities generated by radiation sources through a Monte Carlo code and impose them automatically into a CFD code. For that, the coupling code had to adapt the Monte Carlo results from the MCNPX mesh to the ANSYS mesh.

During some weeks I worked on correcting and completing the numerical treatment of the MCNPX spherical mesh tally for obtaining the interpolation results that had to be implemented in the ANSYS mesh. The problem to solve was challenging and very interesting as it required to go back to mathematical principles that are not usually used in the typical engineering tasks. It also allowed me to use the coding skills I had gained during my internship in the CEA.

## 3.4. Debugging of ITER MELCOR models for TBM analyses

In the last weeks a new project has started consisting of the debugging of ITER MELCOR models from Windows to Linux and of using them to simulate different accidental scenarios. The aim is to generate sets of functions that will be used later on by the Tritium Breeder Blanket (TBM) team to carry out other analyses.

The accidental scenarios to be considered are an ex-vessel LOCA in the TBM Port Cell (PC), a Loss Of Off-site Power (LOOP) and an in-vessel first wall 10 cooling pipes break.

The first thing that has to be done is to analyze the reference documentation and check if the three postulated events are completely defined and no input data is missing. Then, the accidental scenarios and the provided input decks will be analyzed to check if the models already contain all the provisions to reproduce the expected thermal-hydraulic behavior and to obtain all the required output parameters. After that the debugging and simulation tasks will starts. It is expected that only the step times and the accidental scenarios definitions will have to be modified even if other problems will probably raise out.

I am the technical manager of this project so I have to supervise the technical part, take care of the financial aspects and be in charge of the communications with the client. This is a new opportunity in my career.

## 3.5. Condenser capacity calculation

Last year, I was asked to calculate the new capacity of a condenser of a cooling system of Ascó NPP after a modification of the loads. A previous analysis on this condenser had already been done by another Idom team so I restarted the calculations using an excel sheet they had generated.

The calculation turned out to be more difficult than expected. The excel sheet had to be corrected to improve the correctness and the precision of the results. A power balance had to be established taking into account efficiencies and thermo hydraulic parameters that depended on temperatures and pressures. So the calculation required several iterations and a macro had to be set up to optimize the process.

All this supposed a quite challenging situation as the time was very limited and many heat transfer and thermo hydraulic concepts had to be reviewed.

## 3.6. Training on nuclear energy

As many people in the Nuclear Services staff has no specific knowledge on nuclear engineering I was in charge of preparing, together with a colleague that had coursed the nuclear intensification, a course on nuclear energy. I used what we have learned in the master to prepare a presentation with an overview of the nuclear energy, the configuration of a PWR nuclear power plant with the explanation of the different systems, structures and components, some concepts on nuclear safety and the description of the nuclear fuel cycle.

# 4. Experience and knowledge

During the internship I have participated in many different projects, for different clients and related with different topics.

From a technical point of view, I have gained a lot of knowledge on materials' degradation processes. I have analyzed and understood many systems of a NPP with a level of detail higher than the one presented in the degree and master courses. I have also been able to transmit my specific knowledge on nuclear energy. Moreover I have developed my capacities to build thermal-hydraulic models with different codes and for different types of nuclear facilities. In the end, I have improved my nuclear knowledge, in particular from a practical point of view and I have developed my engineering judgment. The tasks developed during the internship were in total compliance with the knowledge acquired during the master.

But what's more, I have gained managerial skills by participating in a very big project, by being in charge of another small project and by contributing to the internal resources management of the department. Now I am much more self-confident and I am able to actively participate in meetings, give my opinion and even take decisions to optimize the work.

I have understood what working in an engineering company means and how complicated is to reach the balance between production and economic results. Finally I have met very different people, with different criteria and professional objectives and I have learned that in the working groups everybody ends up having a fixed role and that maintaining a good ambience is essential for the correct development of the tasks.

# 5. Conclusions

The development of the internship has resulted very positive due to the following reasons:

- I have been able to work on real-life projects directly related with what I have studied at the university these last years,
- I have developed my nuclear technical knowledge,
- I have gained managerial skills,
- And I have met very nice people.

In the end I think I have demonstrated good technical capacities and a certain managerial potential. I think I have perfectly met the expectations and the objectives for a junior engineer, I have developed high quality job and I have been pro-active to gain more responsabilities.

The academic background and the skills developed during the Master and previous studies have been enough to develop the internship comfortably.