Neutron radiography at the "Institut de Maintenance Aéronautique"

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Abstract

Recently the French Institut de Maintenance Aéronautique (IMA) decided to open a new field of research specially devoted to the inspection methods that should be used by the aircraft overhauling industry. Taking into account its proved ability for an early corrosion detection, neutron radiography (NR) was selected as an inspection method to be appraised. This paper presents the approach that IMA intends to follow for achieving this objective and involving selection of equipment, design of the facility and research program.

1 Introduction of the "Institut de Maintenance Aéronautique".

The French "Institut de Maintenance Aéronautique" (IMA), is a Physics Branch Department of the Bordeaux-1 University. It is located in Mérignac, a city in the district of Bordeaux, quite near to the International Mérignac Airport. Its activities are developed in aeronautic field through four different ways.

a-First, IMA is a training center for turning out executives of the aircraft overhauling industry. It leads its students to the title of engineer at the master degree level. The training course meets the level C of the new JAR\(^1\) 66 regulation

b-Secondly, IMA is a center for designing and producing new educative tools. For instance IMA supplied the Airbus Training Center with interactive computer based teaching aids.

c-Thirdly, IMA fulfills research and development studies for the benefit of small and middle companies, thanks to its laboratories specialized in engines, mechanics, hydraulics, and so on.

d-Last but not least, IMA is also a center for technology transfers from University to industry. An international society called Specialized Training in Aeronautics and Research (STAR), was created so as to make easy the cooperation between University and private companies. STAR is an Enterprise-University Training Partnership (EUTP) in the field of space and aeronautics. It is the only EUTP supported by the European Union (Comett Program) in this field of activity. It includes more than 200 industrial and university members located in 18 countries. STAR, as well as the French STAR society have their headquarters at IMA. By the way of STAR and with the help of its partners, IMA has implemented several projects leading every time to an additional expertise.

At the present time, three new projects are to be started subject to get the necessary budget:

1- The use of modern teaching tools for pilot training (multimedia, simulator,..)

2- Practice of LASER in aeronautics and space industry.

3- Practice of neutron radiography in aeronautic and space industry.

\(^1\) The "Joint Aviation Requirements" (JARs) are the new European standards for airlines taking effect from 2.000/2.001. The JAR 66 is related to the training of engineers.
2- Neutron radiography at IMA.

As said before, IMA is an institute mainly devoted to the training of aircraft overhauling agents. These people are educated in many technological fields but usually they have a poor knowledge in Nuclear Physics. Then, when IMA decided to fit out a Non Destructive Testing Laboratory (NDT Lab.) with a neutron radiography (NR) ability, the project manager in charge of this action looked for an equipment easy to use and characterized by the less possible safety nuclear constraints. With such a requirement, a small machine based on the use of a sealed-tube neutron generator (STNG) was a good choice. This neutron source is indeed very similar to an industrial X-ray generator quite usual in NDT implementation. Both these equipment are on-off sources emitting ionizing radiation and need a specific shielding moreover they are built with the same architecture and operate with the same ergonomy as well. Then, IMA got in touch with the SODERN French company which could supply it with a STNG or even with a small NR system (DIANE system). Recently a cooperation agreement has been reached, by which this company will place its own STNG prototype, type GENIE 46, [1], (see Figure 2a), and its imaging systems [2] at the disposal of the future NDT Laboratory. For its part, IMA will build a facility, (see Figure 1 and 2c), and manufacture a DIANE equipment with an upgraded design [3], (see Figure 2b). At the present time, this project is supported by the University of Bordeaux-1 and submitted to the French Department of Education and Science for an official recognition. At the same time the first steps was taken to get the necessary budget with a good hope to succeed.

3- Applied research program at IMA.

Subject to get its NDT facility, IMA intends to undertake applied research that meets unsatisfied requirements of aircraft overhauling activity in cooperation with maintenance industry. Whatever study is begun, the corresponding research program will be lead in cooperation with a company acknowledged as a major in the approached field. This partnership will make sure that the problem to be solved is actual and the expected solution is acceptable by industry. At the same time the cooperation will be extended to any appropriate laboratory if a specific expertise is needed, what is expected in many cases. A first list of subjects supposed to be of interest for industrial companies has been drawn in two classes involving either the "NDT implementation" or the "Improvement of the inspection tools".

3-1 NDT implementation.

Three subjects are expected to be initiated in this class.

a-Detection of hidden corrosion in aeronautic structures: In some already known cases, corrosion attacks cannot be effectively detected with the usual NDT methods (X-ray, ultrasonic, eddy current). It is the case for instance for the intergranular corrosion or for corrosion which lies between two thick overlapping metallic plates. Many times such a corrosion hits aging aircraft due to material fatigue under mechanical strains. This worrying phenomenon caused several aeronautic disasters in the last fifteen years and remains difficult to detect at the present time even thought it was very soon proved that NR could help to solve this problem [4]. After the above mentioned crashes, the FAA lead a tremendous program in USA called the “National Aging Aircraft Research Program Plan” (NAARPP) and, in a former step, the study of NR capabilities was considered, but later, this field of research was withdrawn, probably due to the lack of industrial equipment but to the lobbying of “green party" as well.

In this field IMA will aim to identify which parts are better inspected with NR than with usual alternative methods, the wanted result being a reduced inspection cost due to an earlier detection or a faster testing. This subject includes several intermediate issues such as: choice of the best implements, setting up of the testing process, design of standards, method acceptance test by the authority, and so on....
Neutron Imaging Methods to Detect Defects in Materials

b- Inspection of aluminum honeycomb structures: In this case it is very well known that NR and X-ray inspections complement each other strikingly. Then, the same kind of research as above should be fruitful, peculiarly for moisture and corrosion detection which are hardly seen with usual NDT methods.

c- Inspection of parts made of composite materials: More and more aircraft parts are made of composite materials even though they are difficult to be inspected and that rather few information is available about the aging effects. Taking into account this fact, it should seem reasonable to explore the potentiality of the NR inspection in this field.

3-2 Improvement of the inspection tools.

Taking into account the design of its NR equipment, IMA will favor the research concerning the systems using a sealed-tube neutron generator but the resulting issues should be of interest for all of the low output systems. It is worth pointing out that from a social point of view, to maintain a very low output is the best way for making it possible and safe the in-plant use of a neutron source. So, from a technical point of view, researches aiming an image improvement are vital for putting up an acceptable performance in the widest possible application field. In this field the study is expected to bear on the thermal neutron source, the imaging systems, and the image processing taking into account the “optical transfer function” of each part of the equipment. Another very interesting study would be to set up some “diagnosis aids” such as computed virtual inspections of sample, or fusion of inspection results from all of the performed methods. In every cases the goal should be a better detection defect, a more accurate measurement or an inspection with a reduced exposure time, but in any way, the actual industrial goal remains a reduced expenses as explained above.

4- Conclusion.

To conclude this paper, it is worth pointing out that the implementation of a so wide research program needs a good knowledge in many specific scientific and technologic fields. That is why IMA intends to be open to any offer of cooperation concerning such a program. From now on for instance, IMA intends to be a partner of the 524-COST Action if agreed by the Management Committee and the French Authority.

References.


Figure 1: Sketch map of the radiology facility; Both thermal neutron and x-ray radiology can be implemented into the inspection room depending on the need.
Figure 2a: Sealed tube neutron generator

Figure 2b: Thermal neutron source

Figure 2c: Sketch map of the plant room

Figure 2: Sketch map of the plant room and its fitting out
Assuring nuclear energy's future through international co-operation

Alt is invited lecture as the introduction to the sixth international meeting entitled Nuclear Energy in Central Europe. Good commercial operation, public information and education are needed to win the confidence of the public, and to attract young people to take over the industry's founding generation. Stimulating international co-operation and transfer of best practices can assure this happens across the whole of the European nuclear industry.
History of Mochovce NPP is quite long and reflects political changes that happened in Europe in the end of 80's. The plant site was chosen in south-west of Slovakia in the frame of Nuclear Industry Development Plan adopted by former Czechoslovak government in 70's. In that time was decided to build in Mochovce four VVER 440/213 units together with other NPP's (Dukovany, Temelin, Kecerovce).

Only two organizations are actively producing standards which are used in neutron radiology (NR): the American Society of Testing and Materials (ASTM) and the International Organization for Standardization (ISO). Six ASTM standards exist that address the neutron radiography method. Two of the ASTM standards have been extensively used world-wide. ISO has a working group which is developing three standards that also address the neutron radiography method. Two of these are currently making their way through the ISO approval system. No ASTM or ISO standards exist for the neutron radioscopic method. Future ASTM standards will address the neutron radioscopic method and neutron radiologic system characterization. It is expected that similar efforts will be undertaken in ISO.
Given the relatively small community providing neutron radiologic services, international cooperation and the need for ISO standards will most likely continue to grow.

Gregoric, M. (Slovenian Nuclear Safety Administration, Ljubljana (SI))
Harmonisation of Slovenian nuclear legislation with EU
International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
Portoroz (SI)
6-9 Sep 1999
p. 25-32

Gortnar, O.; Stritar, A. (eds)(Nuclear Society of Slovenia)
European Nuclear Society; Ministry of Science and Technology of Slovenia, Ljubljana (SI); Ministry of Economic Affairs of Slovenia, Ljubljana (SI); Inst. Jozef Stefan, Ljubljana (SI); Slovenian Nuclear Safety Administration, Ljubljana (SI); Agency for Radwaste Management, Ljubljana (SI); ENCONET Consulting GmbH, Vienna (AT); SIAP d.o.o, Pesnica pri Mariboru (SI); S-NET Internet Provider, Ljubljana (SI)
Nuclear Society of Slovenia, Ljubljana (SI)
International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
Portoroz (SI)
6-9 Sep 1999
p. 33-46

Rozman, S. (NPP Krsko (SI))
Krsko modernization project
International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
Portoroz (SI)
6-9 Sep 1999
p. 33-46
Presented are the activities for NPP Krsko modernization project which covers Steam Generators replacement and power increase for 6%.

The new program system CASCADE-3D (Core Analysis & Safety Codes for Advanced Design Evaluation) links some of Siemens advanced code packages for in-core fuel management and accident
analysis: SAV95, PANBOX/COBRA and RELAP5. Consequently by using CASCADE-3D the potential of modern fuel assemblies and in-core fuel management strategies can be much better utilized because safety margins which had been reduced due to conservative methods are now predicted more accurately. By this innovative code system the customers can now take full advantage of the recent progress in fuel assembly design and in-core fuel management. (author)

001^S10200008
008^S22/01/1/AM/K
009^A
100^T Trkov, A.; Aldama, D.L. (Inst. Jozef Stefan, Ljubljana (SI))
200^D Definition of pseudo fission product data for reactor calculations
210^I International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
211^P Portoroz (SI)
213^6-9 Sep 1999
500^p. 57-62
600^E (EN)
610^S refs., 2 tabs., 2 figs.
009^M
100^G Gortnar, O.; Stritar, A. (eds) (Nuclear Society of Slovenia)
109^E European Nuclear Society; Ministry of Science and Technology of Slovenia, Ljubljana (SI); Ministry of Economic Affairs of Slovenia, Ljubljana (SI); Inst. Jozef Stefan, Ljubljana (SI); Slovenian Nuclear Safety Administration, Ljubljana (SI); Agency for Radwaste Management, Ljubljana (SI); ENCONET Consulting GmbH, Vienna (AT); SIAP d.o.o, Pesnica pri Mariboru (SI); S-NET Internet Provider, Ljubljana (SI)
110^N Nuclear Society of Slovenia, Ljubljana (SI)
200^I International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
300^I INIS-SI--02-002
401^L Ljubljana (SI)
402^N Nuclear Society of Slovenia (SI)
403^1999
500^S 683 p.
611^A Available from Nuclear Society of Slovenia, Jozef Stefan Institute, Jamova 39, Ljubljana (SI)
009^9
800^F FISSION PRODUCTS; PLUTONIUM RECYCLE; BENCHMARKS; FISSION; PLUTONIUM 242; REACTOR CORES; N CODES; A CODES
009^X/EN
860^A In the WIMS-D library the important fission products are treated explicitly. The remaining ones are lumped into a single pseudo fission product. The methods and the criteria for defining the pseudo fission product data are described. The data based on ENDF/B-VI and JEF-2.2 evaluated nuclear data files are processed and the WIMS-D library is updated accordingly. Some preliminary results of the NEA/OECD Plutonium Recycling Benchmark are presented. (author)

001^S10200009
008^S21/01/1/AM/K
009^A
100^B Bace, M.; Pevec, D.; Trontl, K. (Dept. of Applied Physics, Faculty of Electrical Engineering and Computing, Univ. of Zagreb (HR))
200^R Radiation dose rates in the vicinity of the NPP Krsko spent fuel pool
210^I International Conference Nuclear Energy in Central Europe 99, V. 1. Proceedings
211^P Portoroz (SI)
213^6-9 Sep 1999
500^p. 63-68
600^E (EN)
Our recent analysis showed that from the criticality standpoint it is possible to increase capacity of the NPP Krsko spent fuel pool by reracking to accommodate spent fuel assemblies for plant lifetime. The reracking will also affect the radiation dose rates in the vicinity of the NPP Krsko spent fuel pool. In this paper we have investigated the radiological impact of reracking using SAS sequences of the SCALE code system. Gamma and neutron dose rates are calculated at different positions close to the spent fuel pool surface for current and reracked spent fuel pool configuration. A comparison of the calculated dose rates and the dose limit in 10 CFR 20 for the restricted work area has been performed. (author)
The nodal diffusion code LEM has been extended with the power feedback option. Thermohydraulic and neutronic coupling is covered with the Reactivity Coefficient Method. Presented are results of the code testing. Verification is done on the typical non-uprated NPP Krsko reload cycles. Results show that the code fulfill objectives arising in the process of reactor core analysis.

The shielding ability and other properties of new high performance neutron shielding materials from the KRAFTON series have been recently published. A comparison of the published experimental and MCNP results for the two materials of the KRAFTON series, with our own calculations has been done. Two control modules of the SCALE-4.4 code system have been used, one of them based on one dimensional radiation transport analysis (SASI) and other based on the three dimensional Monte Carlo method (SAS3). The comparison of the calculated neutron dose equivalent rates shows a good agreement between experimental and calculated results for the KRAFTON-N2 material. Our results indicate that the N2-M-N2 sandwich type is approximately 10% inferior as neutron shield to the KRAFTON-N2 material. All values of neutron dose equivalent obtained by SAS1 are approximately 25% lower in comparison with the SAS3 results, which indicates proportions of discrepancies introduced by one-dimensional geometry approximation.