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of China Institute of Atomic Energy

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Editorial Committee of Annual Report of China Institute of Atomic Energy

PREFACE

In 2002, new progresses and achievements have been made in scientific research, construction of gigantic scientific projects, R & D of nuclear applications, operation of nuclear facilities and others related to rear service in China Institute of Atomic Energy (CIAE). Mainly as follows:

1 Prizes, Publications and Patents

One 2nd grade prize of national science and technology progress, two 1st grade, one 2nd grade and seven 3rd grade prizes of the national defense science and technology progress and one 3rd grade prize of science and technology progress of Beijing are awarded.

A tall of 256 theses were published and 92 published abroad. A tall of 65 theses were embodied by SCI.

Seven patents were applied for and four has been authorized.

2 International Academic Exchanges

A tall of 605 foreign visitors from 31 countries or regions were received for academic exchange or trade negotiation. It is 21.7% of increasing compared with the year of 2001. A tall of 320 scientific workers were sent abroad for scientific visits, international conference or symposium and advanced training. It is 15.5% of increasing compared with last year. Eight agreements or memorandums on scientific and technical cooperation were signed with the institutions from USA, Russia, Italy, ect.. Seven international symposiums or training courses were sponsored.

3 Progresses in the Construction of Gigantic Nuclear Scientific Projects and Technical Remake Projects

Remarkable progress has been made in the construction of gigantic nuclear scientific projects and technical remake projects.

(1) The construction of four gigantic scientific projects

The constructions of four gigantic nuclear scientific projects, China Experimental Fast Reactor (CEFR), China Advanced Research Reactor (CARR), Beijing Tandem Accelerator Upgrading Project (BTUP) and China Radiochemistry Reprocessing Laboratory (CRARL), were smoothly going on:

The milestone point of the construction of CEFR has been brought by completing the top layer of nuclear island building on August 15, 2002.

The ceremony of CARR construction beginning was held on August 26, 2002, which marks that the CARR project has got into the constructing stage.

The authorities concerned has asked China International Engineering Consulting Corporation to evaluate the proposals of BTUP and CRARL in April, 2002, which marks that the itemization procedure of these two projects has officially begun.

(2) Technical remake projects

All technical remake projects went on according to their scheduled time table.

The replacement of HI-13 tandem accelerator tubes was entirely completed. The terminal voltage reached 15.07 MeV. And several beams have been supplied to 8 subjects of scientific research for 754 hours.

The annual plan of XXX project which is a national priority project was completely fulfilled.

The construction of the project for treating radioactive waste liquids went on under the annual plan.

The main items of 46# reprocessing laboratory remake were accomplished.

The preparation of 45# experimental building remake was finished.

The proposal for the shipout of spent fuel in CIAE has been approved.

The mighty advance on the itemization of the first stage remake of infrastructure facilities for supplying of water, electricity, vapour, heating and communication & network system has been made.

The proposal for the renew of facilities for the management of radioactive wastes has been evaluated. And some of projects about the proposal have been approved and begun to put into practice.

4 Hi-tech and Fundamental or Applied Research

In 2002, there were more than 100 projects concerning on Hi-tech and fundamental or applied research undertaken. Most of them were successfully carried on according to their annual plan. A number of positive results have been yielded in some of priority projects.

The projects of accelerator-driven radioactive clean nuclear power system (ADS) and physics on radioactive nuclear beam & nuclear astrophysics, two of projects of major state basic research development program, were evaluated and adopted for two years task by the authorities concerned in June, 2002. The plan and the budget for these two projects for later three years of the 10^{th} five-year-plan has been determined.

The project of study of a middle energy intensity proton linac accelerator, one of projects of nation natural science foundation of China, has been completely accomplished. And the fruit full results have been yielded in research on radioactive nuclear beam, another project of nation natural science foundation of China. An outstanding scientific team which consists of younger scientific workers has been established by performing the projects, which lays down a solid foundation for the future.

All projects of pre-research on national defense undertaken in 2001 were comprehensively examined and accepted. Ones authorized in 2002 were conducted successfully and a number of stage out come has been acquired.

The whole "Heaven-Light" KrF excimer laser system stably operated 700 pulses in the year. Beam uniformity got significantly improved to less than 2% for one beam on the target with use of FEISI beam-smoothing technology.

The proposal for study on advanced fuel assemblies for China PWR nuclear plant, one of the priority projects of development in nuclear energy, was approved.

The investigation on technologies applied in active serviced nuclear plant ,the investigation on mixed oxide fuel technologies and the study on the technology of radiation protection and radiation safety in nuclear plants , also the projects of development in nuclear energy, were conducted successfully.

The investigation on welding technology between different metals for nuclear power, the study on nuclear applied technique in detecting explosives and the research on accelerator technology, nuclear physics, and nuclear chemistry were performed smoothly.

5 R & D of Nuclear Applications

Following the R & D strategy of nuclear applications in CIAE, "making sure that one aim is fulfilled, to make two systems, to develop three domains and to establish four centers", all workers and staff members working on nuclear applications made great efforts to the goal of creating new technology, developing high-technology and realizing industrialization. The significant breakthroughs in the field of nuclear applications have been made.

(1) Reforming system and the high-technology industrialization

The system reformation of isotope related industry was carried out smoothly. All needed procedures including legal ones, land remisement, assets evaluation and audit have been completed. The proposal has been approved by China National Nuclear Corporation. The resolution of purchasing isotope estates related to industry was discussed and adopted by the board of directors, Beijing Atom Hi Tech Co. Ltd

As a pilot unit, the zirconium oxide laboratory was transformed into a simulative limited corporation. Expectant goal was attained in one-year trial.

(2) Construction of industry base

The estates of 32 MU and two buildings on it were purchased in Beijing Zhongguancun Fengtai Science Park in June 2002 for setting up institute Science Park. Work in first stage of property management began and the plan for the projects with great advantages to set up in the park is being made.

A pilot base of container inspection system with ^{60}Co gamma rays has been set up in the institute.

Base demonstration for irradiation sterilization accelerator is being planned.

(3) Key projects and prospect projects

The intent or agent agreements for the project of container inspection system with ^{60}Co gamma rays, probably one of the new increasing points of nuclear applications in CIAE, have been signed.

The project of self-shielding electron beam irradiation facility for killing anthrax spores in mails has been examined and adopted by the authorities concerned and was put in use in a key department in home land.

The new progresses have been made in the development of isotope products.

The development of the system for radioactivity inspection has been completed and available to the user.

The research on principle of prototype instrument for detecting explosives has been completed.

The Primary physical design of 10 MeV medical cyclotrons has been finished. And the key technical problems of the project of automotive oxidation sensor have been resolved.

Besides, our institute owned the first grade prize of Beijing Golden Bridge Prize for Technical Market once again. And output value of nuclear applications in the year was up to 197 million RMB.

6 New Achievements in Rear Service

The positivation and creation was widely transfered by the persons of logistic system carrying out the activity of management perfected, service graded, environment beautified and making all customers satisfy . The new achievements have been made in rear service.

A new culture square, and a new center for literary activity have been set up and used.

A tall of 65 special items such as fixing houses, maintaining equipment and facilities have been completed.

The supply of water, electricity, vapor, heating, goods and materials, the medical treatment, ect. was

sufficiently provided, which powerfully supports scientific research and production.

7 Operation of scientific research facilities

The heavy water research reactor ran safely for 3 656 h. The swimming pool reactor operated safely for 2 487 h. The HI-13 tandem accelerator provided about 1 500 hours' beam for physicists to their scientific research under the condition of replacing its tubes. Zero-power facilities, miniature neutron source reactor, radioactive wastes disposal facilities, isotope production lines, cobalt source and all accelerators operated safely. The communication and network system was improved and ran smoothly.

Professor
Editor in chief
President, CIAE

June, 2003

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IMPORTANT NUCLEAR SCIENCE ENGINEERING

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Radioactive Waste Treatment and Disposal

Isotopes

IMPORTANT NUCLEAR SCIENCE ENGINEERING

Chinese Experimental Fast Reactor(CEFR)

1 Corrosion Verification Test for the Welds of CEFR Sodium Storage Tank and Sodium Drainage Under the First-Grade Accident

Material Group of Sodium Technology, CEFR

The main purpose of this test is to observe and analyze the compatibility between the welds and high temperature sodium at the simulated realistic working conditions of CEFR sodium storage tank and sodium drainage under the first-grade accident. The observation and analysis are focused on the intergranular corrosion at the weld and its heat affection region, in order to provide the test basis for the safe operation and analysis of CEFR .

1 Test methods

1) Facility

According to the test require, two autoclaves made of 0Cr18Ni9 SS and with sodium inlet pipe and gas outlet pipe were designed, and set up in the primary stove used for the high temperature sodium test. The capacities of the autoclaves are is 1.9 and 1.1 L, respectively. Before the test, the inner-surface of the autoclaves was cleaned according to 6.12 section of "Cleaning Technology Condition of CEFR Fluid System and Their Related Components" .

2) Specimens

The weld technology of the 304 SS and 0Cr18Ni9 SS weld specimens is the same as that of CEFR component' s. The size of the specimens is 40 mm×10 mm×3 mm, they are cleaned before test on the basis of the 6.13 section of "Cleaning Technology Condition of CEFR Fluid System and Their Related Components" .

3) Test conditions

Temperature and medium, 425 ℃, Na; oxygen content in sodium, 14.4 μg/g; carbon content in sodium, <10 μg/g; area to volume ratio, 1/20 cm^{-1}; test periods, 3 000 h.

4) Preparation of tests

The quantitative pure sodium and the specimens were put into the autoclaves in a glove box system with the inert gas purification, and welded the inlet and outlet pipes by a cold -welding pliers , then, the autoclaves were removed from the glove box and welded by argon arc, finally, the autoclaves containing sodium and the specimens were set-up into the stove for the compatibility tests.

2 Test results

The specimens after the compatibility tests for 3 000 h are removed from the sodium and cleaned with the alcohol. Then the following analyses are performed for the specimens.

1) Macroscopic corrosion morphology

After the compatibility tests in high temperature sodium, all the specimens lost its primary varnish, their surface are smooth and no evidence of the corrosion.

2) Corrosion rate

The weight variation of the specimens is a little, and their corrosion rates for 3 000 h are in the range of $1.2\times10^{-4}\sim7.4\times10^{-5}$ mm/a. According to the ten- grad criteria of metal material corrosion resistant,

they belong to the first- grade .

3) Corrosion products

The X-ray diffraction analysis of the specimens' surface indicated that there are little Fe_2C and Fe_3C on the surface of 304 SS and 0Cr18Ni9SS, other corrosion products are not found.

4) Microstructure and corrosion morphology

The observation of the microstructure and corrosion morphology indicated that all surfaces which contacted with sodium are no intergranular corrosion. The weld range shows the arbores cent grain austenitic structure, the austenitic grains in the heat affection range become large distinctly and there are some stripe phases in this range. The surfaces of all the specimens tested in sodium are no much change compare with that of the primaries.

2 Analysis of Nitrogen in Sodium by Spectrophotometry

XIE Chun, JIA Yun-teng

Sodium sample in which nitrogen exists in form of sodium nitride, lithium nitride and calcium nitride is solved by distilled water and produce ammonia. Ammonia is relieved when solution is heated, then it is absorbed by hydrochloric acid to produce ammonium chloride. In alkaline solution, ammonium chloride converts into ammonia. Ammonia reacts with hypochlorite and phenol that produces a blue indophenol. Nitrogen is determined by 751G type spectrophotometry at the absorption wavelength of 635 nm.

The work condition of 751G type spectroscopy, colorimetric condition, structure of the apparatus dissolving and distilling sample are well chosen. Recovery experiment is finished in order to verify gastight of the apparatus and accuracy of the method. Recovery rate is 88.0%～102.0%. Relative standard deviation is ±15.8%.The analytical method can satisfy quality standard of nitrogen in reactor grade sodium（≤10 μg/g）.

Nitrogen in sodium produced by Inner-Mongolia and Luoyang is analyzed by the method. Nitrogen content in sodium produced by Iner-Mongolia is 4.8 μg/g. Nitrogen content in sodium produced by Luoyang is 4.0 μg/g. Relative standard deviation of contents nitrogen in sodium is 19.1% and 19.7% respectively, that meet the requirement of CEFR（≤±20%）. Therefore, it is feasible that the analytical method is used to determinate nitrogen impurity in industry sodium and reactor grade sodium.

3 Two Types of Test Assembly Checked and Accepted for CEFR

XIE Guang-shan

The detail design of two types of test assembly used in the simulating transportation, and the mounting and hydraulic test were completed in 2002. This two types of test assembly are manufactured in shanghai No.1 machine tool works, and checked and accepted in March 2003. The former is used in the simulating transportation for CEFR fuel assembly from Manzhouli to Beijing. Its structure, size, mass and manufacturing process are identical with CEFR fuel assembly, but the copper and lead material use a substitute for UO_2 fuel pellet in this test assembly. The latter is used in the mounting, hydraulic and handling test for CEFR fuel assembly, and eliminates admixture in liquid sodium. Its outer shape-size and