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A REVIEW OF FAST REACTOR ACTIVITIES IN ITALY

F. PIERANTONI, R. TAVONI
Comitato Nazionale per la Ricerca e lo Sviluppo dell'Energia Nucleare e delle Energie Alternative,
Bologna, Italy

Abstract

Italy's total primary energy demand increased in 1989 by 2.8% continuing the trend initiated in 1984. Net electricity import increased by 9% reaching the total of 34 TWh, equivalent to the electrical production of 5 power stations in base load operation. As known, after the Chernobyl accident, a moratorium of at least 5 years was imposed on the construction of new nuclear reactors in Italy. The PEN (National Energy Plan), already approved by the government and submitted to parliament for discussion, calls for a programme of research and industrial development of reactors with inherent and passive safety features. In this framework during 1989, a collaboration of ENEL, Ansaldo and ENEA with some designers of innovative reactors, mainly water-cooled, has taken place in many fields. The Italian participation and contribution in international groups has continued with the aim of maintaining and updating the know-how on the most relevent themes of research. Contacts are underway in the area of advanced reactors with several countries such as the USA, the FRG, the UK and France. With France an agreement for cooperation in the area of future nuclear reactors and advanced technologies for the upgrading of industries was signed in April 1990.

1. Energy consumption in Italy

Italy's total primary energy demand increased in 1989 by 2.8% (see table 1) continuing the trend initiated in 1984. This demand can be compared to a GNP increase in real terms of 3.3% resulting in a consequent reduction of the energy intensity.
In the last year the difference in oil consumption between Italy and the other countries in the European Community, already large, has increased still further.
Net electricity import increased by 9% reaching the total of 34 TWh, equivalent to the electrical production of 5 power stations in base load operation.

Table 1 - Primary energy requirements[1] in Italy during 1988 and 1989[2]

	1988 Mtep	1988 %	1989 Mtep	1989 %
Oil derivatives	91.0	57.8	93.6	57.8
Natural gas	34.2	21.7	37.0	22.9
Solid fuels	15.1	9.6	14.7	9.1
Primary electricity[3]	10.2	6.5	9.0	5.6
-Hydro	(9.5)	(6.0)	(8.3)	(5.1)
-Geo	(0.7)	(0.5)	(0.7)	(0.5)
-Nuclear	-	-	-	-
Net electicity import	6.9	4.4	7.5	4.6
TOTAL	**157.4**	**100.0**	**161.8**	**100.0**

/1/ Including storage reserves
/2/ Provisional data
/3/ 0.22kgep/kwh

The increase of the primary energy demand in Italy has mainly been determined by the increase in the final consumption of the transport sector with a minor contribution from the industrial sector.
During 1989 electricity demand (see table 2) increased by 3.9%; once again this is a value higher than the total primary energy increase.
An important reduction in the hydroelectric production has taken place with a decrease of 5.7 tWh (-13.6%) and as a consequence the thermoelectric production has increased from 156.0 TWh to 170.1 (+8.4%) now covering more than 80% of the total electric production.
The share of hydrocarbon fuels (oil and natural gas) in the total electric production has reached 65% thus representing an exceedingly high value.
The direct import of electricity of 33,8 TWh has reached 14.8% of the total consumption and it comes mainly from Switzerland, France and FRG.

Table 2 - Electricity production and demand in Italy during 1988 and 1989[1]

	1988 TWh	1988 %	1989 TWh	1989 %
Thermoelectric Energy	156.9	77.1	170.1	80.6
-Oil derivatives	89.8	44.1	103.0	48.8
-Natural gas	32.4	15.9	34.2	16.2
-Solid fuels[2]	34.7	17.1	32.9	15.6
Primary Electricity	46.5	22.9	40.9	19.4
-Hydro	43.4	21.4	37.7	17.9
-Geo	3.1	1.5	3.2	1.5
-Nuclear	-	-	-	-
Total Gross Production	203.4	100.0	211.0	100.0
Net Electricity Import	+31.3		+33.8	
Total Availability	234.7		244.8	
Energy used by auxiliary production services and by pumping	-14.3		-15.7	
Network demand	220.4		229.1	

/1/ Provisional data
/2/ Coal, lignite and others

In order to stimulate private production, the prices of electrical energy sold by private producers to ENEL (the national pubblic utility), have been increased. From the 1st August 1989 ENEL has had to pay for this electrical energy according to the average production cost.

2. The nuclear situation in Italy

As known, after the Chernobyl accident, a moratorium of at least 5 years was imposed on the construction of new neclear reactors in Italy. The PEN (National Energy Plan), already approved by the government

and submitted to parliament for discussion, calls for a programme of research and industrial development of reactors with inherent and passive safety features. In this framework during 1989, a collaboration of ENEL, Ansaldo and ENEA with some designers of innovative reactors, mainly water-cooled, has taken place in many fields.
The Italian participation and contribution in international groups has continued with the aim of maintaining and updating the know-how on the most relevant themes of research.
Contacts are underway in the area of advanced reactors with several countries such as the USA, the FRG, the UK and France. With France an agreement for cooperation in the area of future nuclear reactors and advanced technologies for the upgrading of industries was signed in April 1990.
The rearrangement of Italian nuclear programmes has also required a deep tranformation of ENEA's structure. A new unit, the Nuclear Area, devoted to R&D on innovative nuclear fission reactors and nuclear fusion has been created. The former Fast Reactor Department has been absorbed by this new Area.

As far as the PEC reactor is concerned, after the decision taken in June 1988 of stopping the plant construction, during 1989 nearly all the residual components totally or partially completed were delivered to ENEA's Brasimone site. The reactor building and the most critical components are being kept in a state of nuclear preservation, but their utilisation for the reactor completion is not considered realistic.
Resources on fast reactors have been dramatically cut down and, at present, some of the activities carried out, being of interest in other R&D fields can be considered of general purpose.
Fast reactor R&D include analysis and evaluation of the possibility of actinide burning with special reference to the implication on the waste disposal problems.

3. Seismic isolation

In 1988 ENEA began to work on seismic isolation, in collaboration with ISMES, because of the Italian seismic situation, the proposals of the new Energy Plan and the possible application to conventional plants. In this framework ENEA, also in collaboration with GE, has prepared a design guideline document for nuclear structures with seismic isolation.
This document is limited, for the moment, to the horizontal directions and to structures employing high dumping elastomer bearings, as it has been foreseen in the modular PRISM reactor and in the first complex of isolated buildings in construction in Italy (SEAT buildings in Ancona).
In the present version of the document, some safety factors, to be used in the design, are not defined yet, and neither are some test parameters and details of the qualification procedures. Indeed, the definition of these items requires specific R&D on numerical models and on the experimental activities. Our experiments are based on the bearing type used for the SEAT buildings at Ancona.
The first phase of the experimental programme (tests on individual bearings) has been defined in detail and the test machine and isolators have been fabricated. The beginning of experiments is foreseen in April 1990. These are aimed at the determination of bearing static and dynamic mechanical properties, the evaluation of scale effects, and the assessment of the significance of the various physical parameters, in order to provide a reliable description of the bearing properties. They will also make it possible to check the adequacy of the test techniques used to evaluate the physical parameters.
Test machine permits to test either single bearings (Fig. 1) or a pair of superposed bearings ("sandwich"), of different sizes. For single bearing tests, it uses a roller slide. It can provide static or dynamic horizontal excitations in one, or for "sandwich", two simultaneous directions normal to one another, under static or dynamic vertical compression load. It is equipped with one actuator for the vertical excitation and with two for the horizontal excitations. The latter actuators can be mounted either in the same direction or in two different directions, perpendicular to one another. The characteristics of the machine are such as to allow large displacements of the bearings. They should enable failure to be attained, even for the full-scale bearings, for at least the one-directional horizontal excitation. The number of bearings for

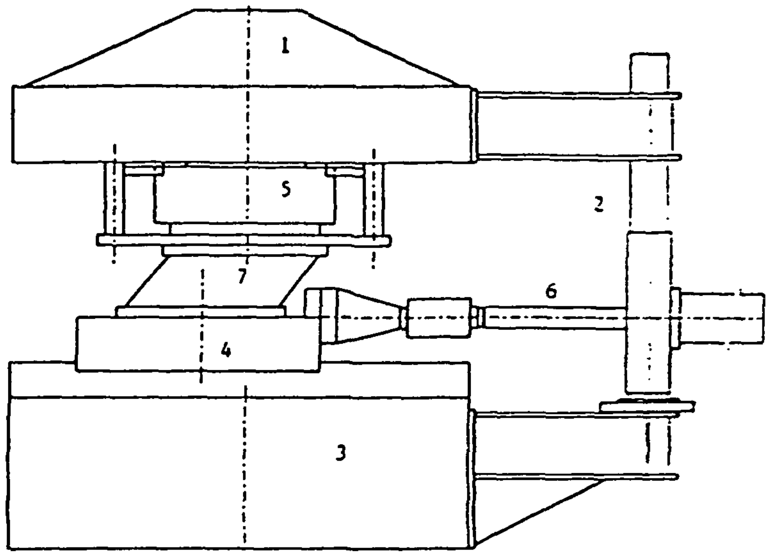

Fig. 1 Sketch of the test machine including bearings (case of single horizontal actuator). 1 = roof; 2 = support for horizontal actuators; 3 = base; 4 = roller slide; 5 = vertical actuator; 6 = horizontal actuator; 7 = bearings.

these tests is 28 in full scale, 22 in 1/2 scale, 20 in 1/3 scale and 40 in 1/4 scale and they have been constructed in Italy.
At the conclusion of the experiments on individual bearings, laboratory tests on scaled structure mock-ups will be performed.
Finally on-site tests will be performed on full scale isolated structure mock-ups.

4. Modular systems studies

As for fast reactors, the Italian interest can be seen from the viewpoint of longer-range energy security.
In this perspective, contacts are underway with those institutions involved in R&D on fast modular reactors with enhanced passive feature. A cooperation with GE is underway on the study of an oxide version of the PRISM core.

The work is subdivided into three phases, the first of which began in the second half of 1989 and is now near to completion. It deals with a better understanding of the oxide core as it was conceived by GE and with the comparison of different calculation methods. The second and third phases to be carried out in the years 1990 and 1991, concern the oxide core optimisation and the final verifications on the optimized design.
As far as the first phase of activity is concerned, the neutronic calculations have been made with the Citation code and Jef-1 or ENDFB-IV cross-section sets. Flux and power values obtained in fissile elements were greater than the GE results, so that further work is underway on the influence of different cross-section sets.
After the neutronic values were normalized, an excellent agreement on the sodium, cladding and fuel temperature distribution has been found.

A further activity has been started concerning the PRISM fission gas monitor device.
The diffusion-based design operates with a static column of gas connecting the cover gas region to a closed end volume in a shielded field of view of a scintillation detector.
A series of conceptual drawings has been produced in order to permit the construction of the device and later on, the experimental tests.

Ansaldo is also collaborating with GE on the following items:
-Verification of the plant safety characteristics with particular consideration of the core shut-down and cooling capability in accidents without scram. Loss of primary flow in different conditions and control rod extraction were studied.
-Dynamic analysis of the reactor block.
-Economic analysis of the principal components of the reactor block.
-Definition of the reference solution of the in-vessel transfer machine. The PEC experience on that subject was helpful. Particular attention has been devoted to seismic analysis of this component.

5. Other activities

METHODS

The data bank system on the reliability of fast reactor components has been implemented during 1989 with the collection of the Phenix component data for the period July 1986 to May 1989.

In the Reactor Physics field, ENEA contributed to the development of a unified European formulaire, with the implementation of the code that combines the probability tables with the cross-section sets provided by the Themis code.

During 1989 the activity in the field of Monte Carlo method development has continued with the introduction of an automatic variance reduction procedure in the MCNP code (involving the production of optimized splitting and Russian roulette parameters).

The work in progress deals with an extension of the method from a surface to a volume parameter model (involving optimization of space/energy importancees). Coupled neutron - gamma problems are also under study.

INTEGRITY OF STRUCTURES

ENEA is involved, under a contract with CEA, in the development and the implementation of the Castem 2000 and Trio systems for analysis respectively in the fields of structural and fluid mechanics.

During 1989 a large effort of systems promotion in Italy has been conducted with a first series of engineering applications in the industrial field. This has been possible on the basis of the previous work that resulted in tested and validated versions completed by full documentation.

The work has been mainly devoted to three different objectives:

-Promotion and diffusion of the systems towards the national industry, universities and research institutions.

-Applications for analysis and verifications of thermomechanical and thermofluid-dynamics.

-Acquisition and implementation of new versions and development of specific new applications.

As for the third point the following actions have been performed:

-Development, implementation and extension of an interface CAD-Casten 2000 by utilizing output standard I.G.E.S.

-Writing of application documents of Castem 2000 containing a theoretical formulation and some application examples for static and linear analysis; non-linear analysis; plasticity; vibration mechanics in free situation for structures, fluids and fluid-structure couplings.

-Execution of an international benchmark for the IAHR group concerning the validation of interpretation models of mixing of stratified currents in the turbolence regime.

-Validation of the Trio System for some fluid dynamics problems.

EFR

As far as the EFR design is concerned, Ansaldo has continued to collaborate on the common activities. A 15 MW heat exchanger for the decay removal has been studied. The U type solution includes 60 tubes with a 42 mm diameter with a total dimension of the DHX of 1040 mm. The thermohydraulic code Bacara is under modification to allow the calculation to be made.

The IHX has straight tubes (4488 tubes with a 17 mm diameter) between two plates. During 1989, Ansaldo has made the thermohydraulic calculation in two dimensions with the code Bacara, and in this way has determined the best bundle configuration to be successively verified thermomechanically.

SPX-1

In association with Novatome, Ansaldo has participated in the detailed design of the fuel transfer vessel that now represents the new solution for the irradiated fuel transfer out of the reactor. Ansaldo must also supply the principal systems and components such as vessel, plug and movement mechanisms and auxiliary circuits. For these components Ansaldo has accomplished the executive design and the mounting studies. Ansaldo has also participated in the maintenance and modification campaigns on the occasion of the programmed shut-down of the reactor after it has reached 160 full power-equivalent days.