STAND FOR VISUAL AND ULTRASONIC TESTING OF SPENT FUEL

W. CZAJKOWSKI and E. BOREK-KRUSZEWSKA
Department of Nuclear Energy
Institute of Atomic Energy, 05-400 OTWOCK-ŚWIERK, Poland

ABSTRACT

Stand for visual and ultrasonic testing of spent fuel, constructed under Strategic Governmental Programme for management of spent fuel and radioactive waste, is presented in the paper.
Stand, named "STEND-1", build up in Institute of Atomic Energy in Świerk, is appointed for underwater visual testing of spent fuel elements type MR6 and WWR by means of TV-CCD camera and image processing system and for ultrasonic scanning of external surface of these elements by means of videoscan immersion transducer and straight UHT connector.
"STEND-1" is built using flexible in use, high-tensile, anodised aluminium profiles. All the profiles feature longitudinal grooves to accommodate connecting elements and for the attachment of accessories at any position. They are also characterised by straight-through core bores for use with standard fastening elements and to accommodate accessory components.
Stand, equipped with automatic control and processing system based on personal computer, may be manually or automatically controlled.
Control system of movements of the camera in the vertical axis and rotational movement of spent fuel element permits to fix chosen location of fuel element with accuracy better than 0.1 mm. High resolution of ultrasonic method allows to record damages of outer surface of order 0.1 mm.
The results of visual testing of spent fuel are recorded on video tape and then may be stored on the hard disc of the personal computer and presented in shape of photo or picture. Only selected damage surfaces of spent fuel elements are tested by means of ultrasonic scanning.
All possibilities of the stand and results of visual testing of spent fuel type WWR are presented in the paper.

1. Introduction

During the operation of two research reactors EWA and MARIA located in INSTITUTE OF ATOMIC ENERGY in Świerk 6300 of fuel elements WWR and MR and Ek-10 type were burnt up. The first part of these elements were moved to wet storage in 1968 and have been stored there till now.

After such a long period of wet storage the decision to investigate the spent fuel elements, by means of possible to use methods, have been taken, to estimate the safe time of wet storage and to decide whether to change this environment into the dry storage.

The technical analysis and analysis of the costs of realization of this task have shown, that maximum information about the condition of all population entire amount of fuel elements will be received by visual testing, ultrasonic scanning of external surface of these elements, and also by investigating checking tightness of each element using measurement of fission products release.

The construction of stand and instrumentation equipment, which have been using to visual testing and ultrasonic scanning of spent fuel elements surface, is presented in the report.

2. Description of "STEND-1"

Stand named "STEND-1" was built using flexible in use, precise, light, anodised aluminium profiles characterized by large stiffness. All the profiles feature longitudinal grooves to accommodate connecting elements and for the attachment of accessories at any position by means of screws. They are also characterised by straight-through core bores for use with standard fastening elements and to accommodate accessory components. These features make possible easy regulation, and allow transfer of the stand to the other pool storage if necessary.

The stand fulfils following requirements:

- testing of spent fuel element up to the length of 1, 5 m under the water-level in pool storage in regard to radiation dose admissible for operator,
- visual testing of spent fuel element is performed using coloured underwater TV – camera; obtained pictures are recorded on SVHS video tape with maximum TV definition of picture that permits to identify fuel element surface damages below 0.1 mm dimensions and to recognise the kind of corrosion,
- ultrasonic scanning of spent fuel element surface makes possible identification of damages, with accuracy bring near visual testing, and measurement of their depths,
- fuel element rotation around vertical axis and TV camera with ultrasonic (UT) probe vertical movement displacement perpendicular to fuel element axis (Z axis direction) is realized by means of computer controlled servomotor; with 1/deg accuracy for rotation movement and 0,1 mm accuracy for Z axis movement,
- supporting structure characterises high ability of mechanical vibration damping, which allowed to scan surface of fuel element without any contact of UT probe with the surface.
- linear velocity of TV camera and the UT probe and the rotation of fuel element is fluent in the wide range of regulation.

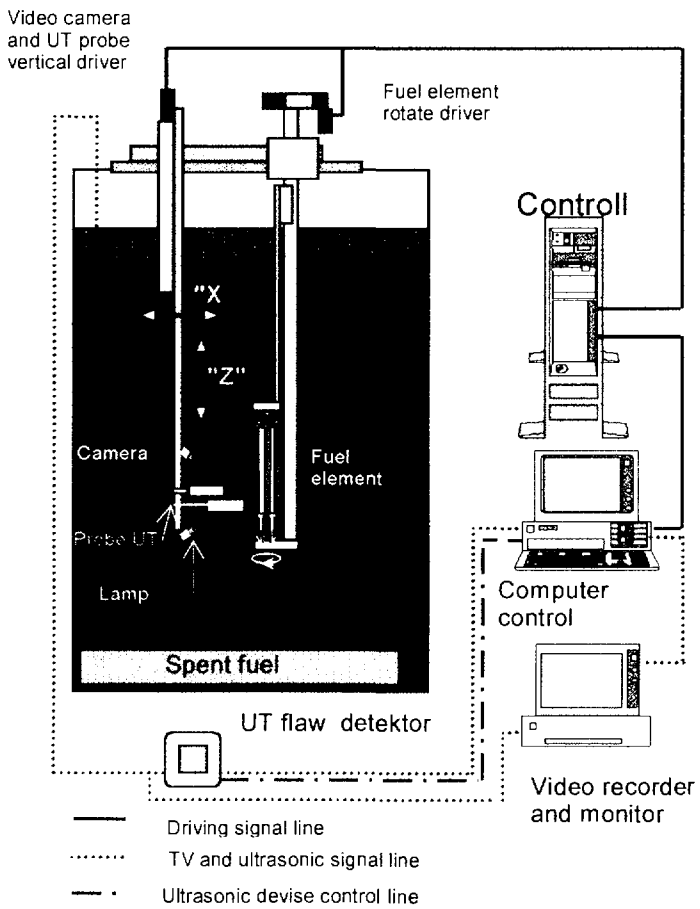

Fig. 1 Schema of STEND 1

Rotation of testing fuel element is provided by servomotor with 2.3 Nm torque and 1500 r.p.m maximum motor speed by used of two belt transmissions, from one of which is mounted under the water level. Total transmission ratio of system: driving motor – holder of fuel element, is 1:25.

Measurement and recording of angle orientation position of fuel element holder is realized by rezolwer installed on the shaft of motor. Its resolution carries out 3600 lines pulses per revolution per rotation and permits to obtain 1/deg accuracy for rotation movement.

TV camera with UT detector vertical movement is also realized by servomotor with 1.7 Nm torque and 750 r.p.m maximum engine speed and by rolling gear with 10 mm per rotation pitch. Measurement and recording of angle orientation position is realized by identical rezolwer. It gives the real accuracy of TV camera and UT probe position equal 0.1 mm. Holder of fuel element consists of two parts. The bottom one consists of an alignment element shift manually in vertical direction. The upper part is connected by the drive shaft with belt transmission and servomotor. Rate and force of closing of fuel element in handle is regulated. Closing force of holder amounts to 30N.

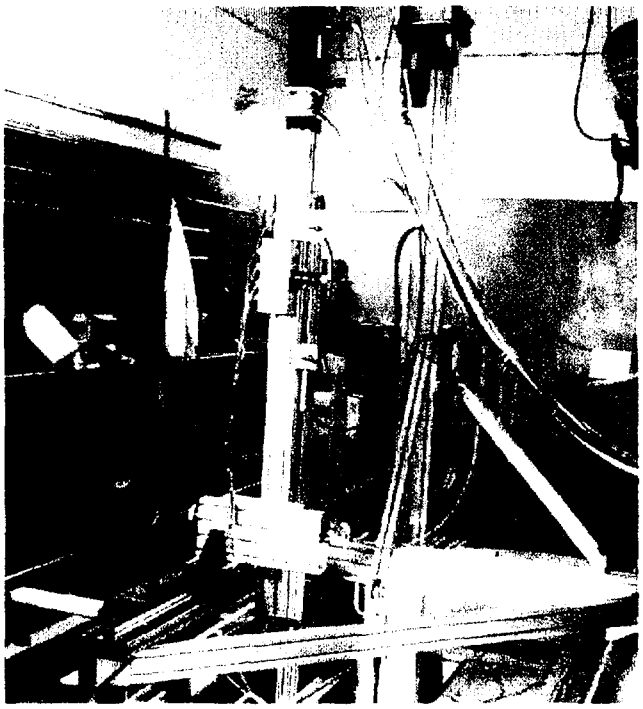

Fig. 2 View of stend in wet storage

The scheme of stand, illustrating location of their main elements and their mutual connections, is presented below in Fig.1. The view of stand situated in wet storage is presented in Fig.2.

Spent fuel elements under testing are computer controlled with special software, written in VISUAL BASIC.

Software contains the following tasks: fuel element movement control, TV camera together with UT probe movement and ultrasonic probe control:

– acquisition and processing data on the form of scanned surface map, what determine the basic idea of working stand and his abilities to be a precise device to remote testing of spent fuel elements.

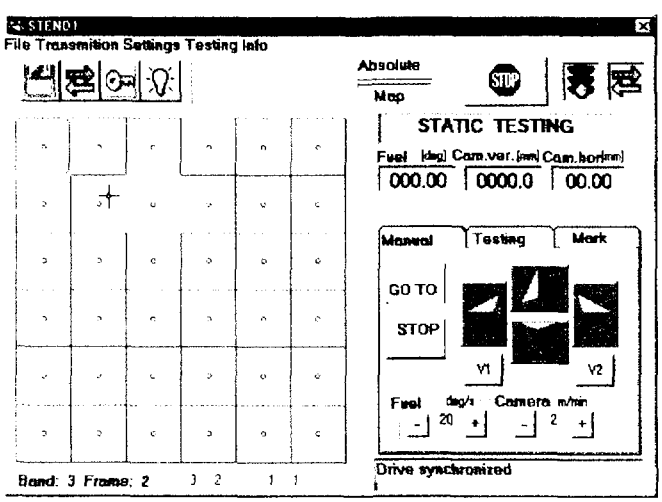

Fig. 3 The main page preview of control program

– choice the kind of testing (visual- static or dynamic, ultrasonic-circumferential or vertical).

The main programme cooperates with programme of synthesis of speech SYNTALK, which imparts all parameters of investigations with voice (official report), and also topical position of camera and UT probe in relation to testing fuel element in select earlier coordinates. Report together with images of testing surface are recorded on video tape. It permits to identify the testing part of fuel element surface during the analysis of results is presented in Fig.4 and 5

3. Optical and image system

Visual testing can be carried out automatically or manually:

– in automatic mode:

DYNAMIC testing- consists in review and recording of condition of all of fuel element surface with the select speed of camera movement, in this instance element surface is divided only on bands,
STATICAL testing – consists in review and recording of surface with camera stop according to programmed algorithm of investigations, in this instance element surface is divided on bands and single frames, what permits on exact identification of observed damages.
– in manual mode of camera and fuel element movements:
testing makes possible observation of interesting area of fuel element surface in unrestricted time, under different angles, and in different intensity of lighting. This mode permits on recording in computer memory select site of surface to further ultrasonic testing and later returning to this place in aim of supersonic scanning and measurement of corrosion pits depth.

Colour camera with screen resolution 800X600 pixel, interchangeable lens and shooting angles of camera (angle of view) 35, 49 or 70 deg (in air) was used to visual testing of spent fuel. It permits on identification of surface damages below 0,1 mm dimension. Camera is placed in hermetic casing. The least distance from camera to testing surface of fuel element, permitting to perform visual testing without visible disturbances of image from radiation field, carries out 250 mm.

Two xenon lamps with regulated power of light from 0 to 100 lux placed diagonal to surface, was used to the best recognize of damages and surface quality.

Observed images are recorded on SVHS magnetic tape, and then numerical processing using LUCIA program. Finally, there are estimated according to worked out in great detail criteria and recorded on CD-ROM discs.
Below, in Fig. 4 and 5 results of visual testing of spent fuel elements type WWR and MR-6, are presented.

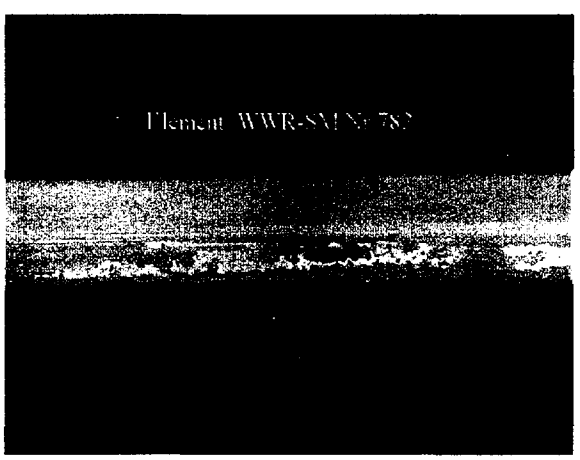

Fig. 4 Image of fuel element WWR

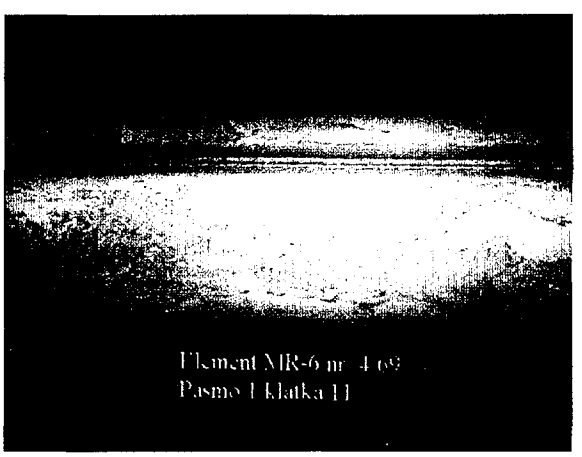

Fig. 5 Image of fuel element

4. Ultrasonic scanning system

Surface of spent fuel element, chosen during visual testing, can be the subject of ultrasonic scanning.

For ultrasonic scanning of fuel element surface which is choosed during visual investigation, use ultrasonic flaw detector equipped with the focusing probe. It operates with frequency ranges 10 and 15 MHz and it is joined with the control computer by means of connector RS 232. Ultrasonic probe is fixed to the jib (along with the tv camera) and it is removable of distance 15 mm from the fuel element surface. Ultrasonic probe concentrates ultrasonic waves in focus in distance of about 15 mm to provide optimum value of maximum vertical and horizontal resolution. Transmission rate of data

measurements to a control computer is 60/sec. This permits to use quick movement of cap of ultrasonic probe in relation to surface of the investigated fuel element. High frequency rate of ultrasonic flaw detector and high preciseness time of measuring permits to attain vertical resolution of about 0.15 mm practically.

Structure and software "STEND1" permits to scan the fuel elements surface with round (MR6) and hexagonal (WWR) shape.
In case of fuel element MR6 the scanning is executed by oscillate movement with relation to its axis in earlier programmed angle. After full cycle the ut probe is being executed automatically on programmed snap (e.g. 0.5 mm).

In case of fuel element WWR the scanning of a flat surface is being executed by support displacement along axis X (e.g. 0.2 mm) and automatic displacement of ut probe by programmed snap responding to the length of scanned fields (e.g. 50 mm). Initiation of this movement induces automatic inclusion of ut flaw detector. In this manner the scanned field is being cover points. Each of those points is represented by appropriate are numerical value which correspond the depth of decreasing of cladding material (pitting corrosion) on the surface of fuel element investigated.

Density of these points depends on programmed speed of the ut probe in relation to scanned surface and distances of paths. A file of one measurements data scanning occupies a space of 1 Mb on hard disc.
Digital recording of scanning is converted into a map or graph and official record.

5. References

[1] B. Jarzembski, Control program STEND 1, OBRUSN - Toruń 1999
[2] S. Mackiewicz, Control program UTV, NDTEST – Warsaw 1999
[3] E.Borek-Kruszewska, S. Chwaszczewski, W. Czajkowski, *Tentative visual testing of spent fuel element WWR-SM type* Raport IEA B nr 39/99, 1999.