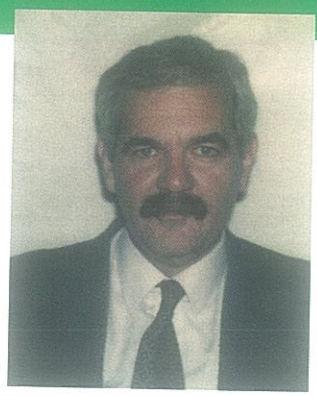


Jacinto MARICALVA GONZALEZ, Industrial Engineer (ETSII - Madrid), specializing in Energy Technologies. He has worked in Ferrovial and Foster Wheeler. He joined ENUSA in 1975 to work on the Construction Project of the Fuel Element Factory in Juzbado (Salamanca). After an initial training phase in USA, he took part in Factory design, licensing and startup. In the Factory, he has held the posts of Programming and Control Manager, and later Production Manager and Deputy Director.
He is currently the Director of this Factory.

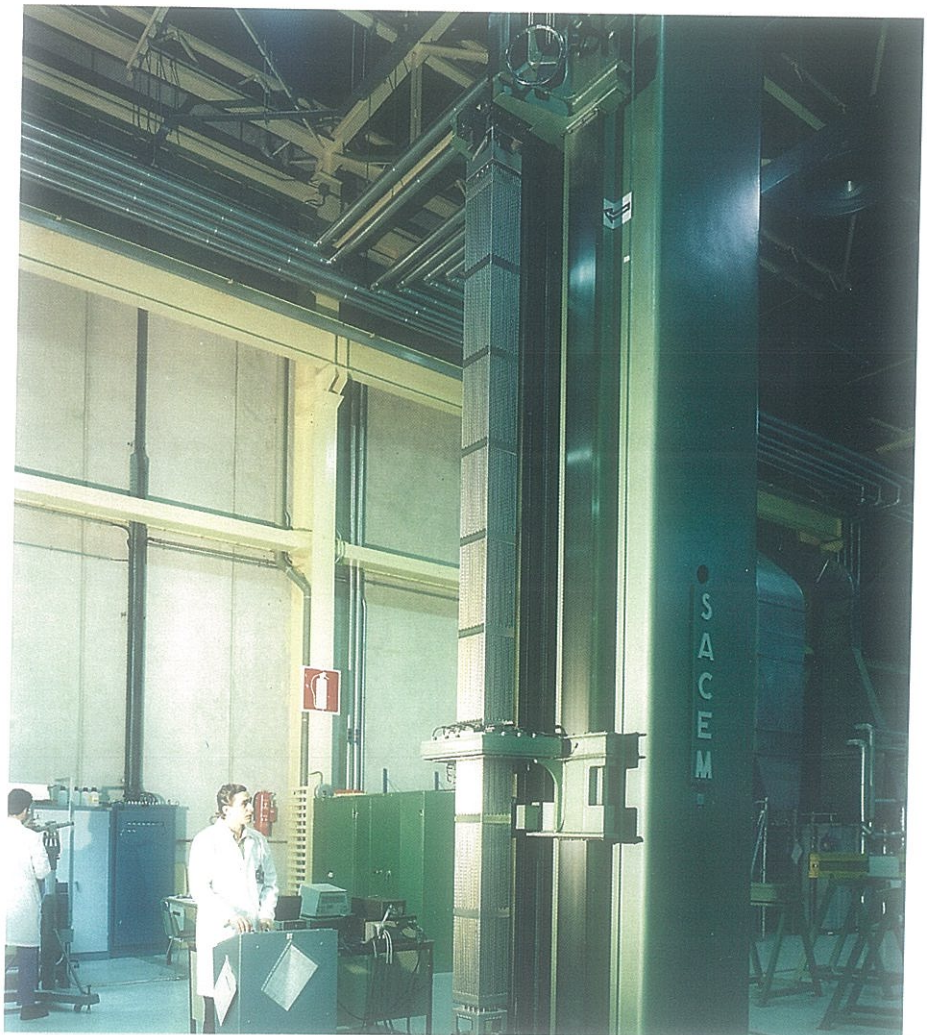
A REPLY TO THE FUEL MARKET CHALLENGE

JUZBADO FUEL MANUFACTURING PLANT

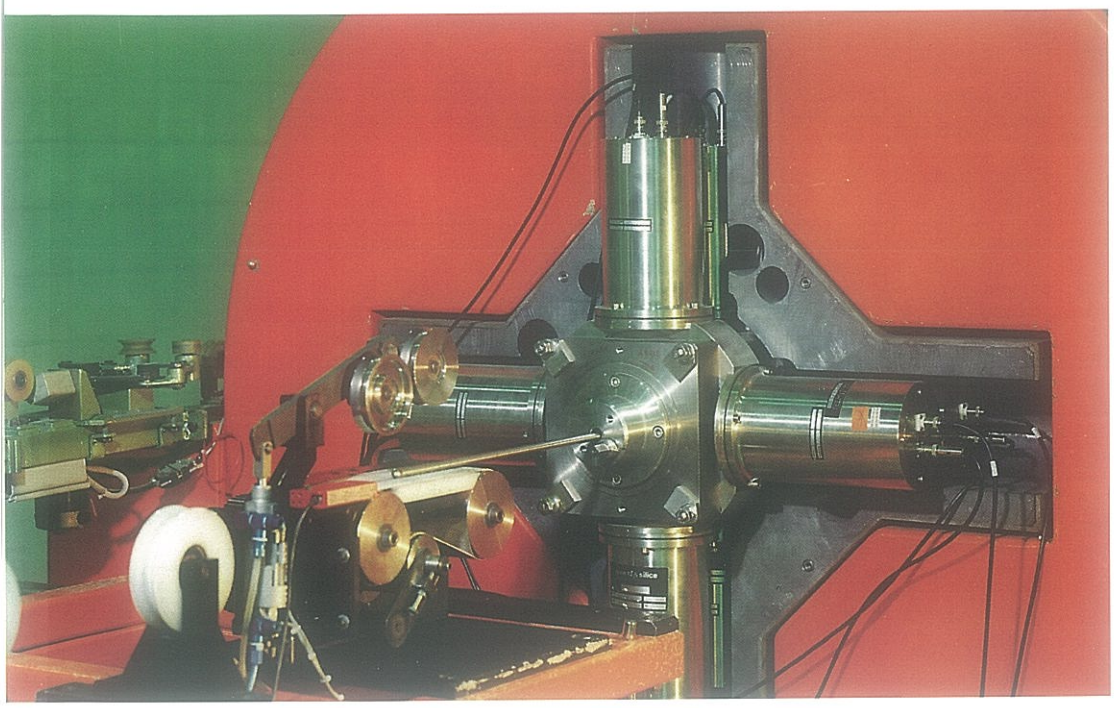
J. MARICALVA

The ENUSA Juzbado Fuel Manufacturing Plant, located in Salamanca, Spain, started its manufacturing activities in 1985. At that moment the only product manufactured was PWR 17x17 fuel, with inconel grids and standard nozzles, and BWR GE-7 fuel, non barrier tubing. The most important features of the plant were:

- Independent lines for PWR and BWR projects
- Two powder types IDR and ADU processing capability
- Different processes for welding, rod loading and final assembly



Final PWR fuel element inspection (Juzbado Factory)



Statistical control of the tablet press process (Juzbado Factory)

- Manual treatment for manufacturing traceability and data management
- Equipment implementation and installation design in relation to nuclear safety and radiological protection according to ALARA criteria.

During the first years, the plant made the following types of fuels: PWR 17x17 STD, 17x17 OFA, 14x14 HIPAR, BWR GE-7, non barrier and barrier, and GE-8 barrier.

The non stop evolution in the design of the fuel assemblies, the fact of working with two technologies and the size of the plant caused some difficulties in such a competitive market.

ENUSA accepted the challenge and now is ready to produce the most advanced products with the highest reliability and also to increase the added value of its manufacturing process. All this was reached by means of training and investment programs that, taking advantage of the knowledge of both technologies, have provided flexibility in the manufacturing processes and a permanent improvement of the process quality and the product itself.

ENUSA, in the past years, has worked in collaboration with GE and W, its technological partners (as well as with Japanese fuel manufacturers) in the revision of the techniques, equipment and processes applied in the Juzbado Plant. This revision has allowed to get a plant with a high technological capability, keeping at the same time the flexibility and dynamism of a small company.

The main developments carried out along the last year as a consequence of this philosophy are summarized here on:

CERAMIC AREA

Pellet Manufacturing

ADU or IDR powder is used according to its particular specification, pellets are sintered in wet or dry hydrogen atmosphere and sintered pellets are ground in wet or dry process. The furnaces and grinders have been designed to work with either kind of powder. In this way the three manufacturing lines can process either ADU or IDR powder.

Pellet manufacturing control is computerized in real time with data entry in all the stations where the material is processed, applying additionally statistical process control in prepress, press and grinding. All the pellet data are processed by computer and it is the computer itself who accepts or rejects each lot.

At present, ENUSA is setting up a new robotic system for pellet handling at the final press and a new sintering furnace to avoid bottlenecks in the ceramic area.

Pellet Inspection

Porosity Control

Due to the new requirements on pellet porosity ENUSA has set up in its laboratories for this purpose a new system based on image analyzing. By means of this new equipment based on techniques of computerized image analyzing the pellet pore size distribution is controlled.

Pellet Diameter Control

Till the last year the pellet diameter control was made through a statistical process by manual sampling in real time. This control is being replaced by a 100% automatic on line control. This system includes a laser micrometer (35 diameter measurements per pellet are made and the maximum, minimum and average value are compared with the limits required by the drawings), a computer, the pellet displacement system, the pellet ejection system and the control automatism.

The system is equipped with a mechanism that automatically rejects the pellets out of tolerance, and has a computer that processes the pellet diameter information, showing it on the screen and sending the final data to the central computer as a traceability record.

FUEL ROD MANUFACTURING

End Plug Manufacturing

Complementing the first automatic CNC (Computer Numerical Control) lathe implemented in 1991, a new more advanced one has been installed to cope with the annual demand of the plant.

The possibility to manufacture locally PWR and BWR end plugs has permitted to optimize their design, reaching the needed flexibility to adapt the end plug design to the welding process.

This new fully automatized CNC lathe incorporates a compensation control tool wear system, a tool monitor system (including tooling presence cutting and rupture control) and an automatic bar feeder system.

BWR Rod Loading

A new laser pellet diameter control system has been installed before the pellets are loaded into the tube, this pre-

cludes the introduction of pellets of different design diameter.

FUEL ROD INSPECTION

UT equipment

ENUSA has recently installed a new UT equipment with rotating transducer head on its BWR rod inspection line. This fully automatic system has two high frequency measurement probes (50 MHz) that inspect the girth welding through longitudinal and transversal UT waves. The system gives the inspection results in numerical and graphical displays.

The information received (100,000 points per weld) is processed by two computer units that create a graphic welding image, print out inspection results and identify the parameters out of specification and accept or reject the welding automatically. The inspection data in the graphic mode are also recorded on a CD-ROM disk for ulterior check.

The UT equipment controls pores, penetration, total porosity, wall thickness and cracks. All these defects are shown graphically on the screen and numerically in the printer.

In addition to the UT inspection, ENUSA maintains the X-Ray inspection to control other welding defects, hardly identified by UT, such as tungsten inclusions.

Similar UT equipment will be used soon to inspect PWR fuel rod welds.

Gamma-Scanner

ENUSA has recently also upgraded the gamma scanner equipment, incorporating the best and more advanced techniques to permit a higher detection capability as well as a higher versatility and performance.

With this purpose, the detection system has been modified, now having 3 INA detectors instead of 2 and 12 photomultipliers instead of 8. The electronic and automatism have also being improved and updated in addition to a new control software.

Gamma scanner for uranium oxide enrichment control (Juzbado Factory)

MECHANICAL AREA

PWR skeleton assembly

The skeleton assembly equipment, equipped with an intelligent control system and digital control positioning, uses different work programs for each type of skeleton assembly (different rod length and patterns for each skeleton assembly). This equipment is composed of a bench to support the skeleton and an expansion device which is able to work with different designs. The existence of different benches minimizes set-up preparation time due to different skeleton designs.

PWR final assembly

ENUSA in the latest years has improved its fuel assembly manufacturing facilities by the installation of new, state of the art, fuel assembly fixtures. These modern equipment incorporates CNC brushless D.C. motors, latest generation PLCs and special design spindle screw and free nuts mechanisms that eliminates vibrations. The fixture can be preprogrammed with specific recipes for every type of bundle so that the rod loading process is fully automatic. The equipment is able to detect abnormal loading conditions in order to avoid any damage to the fuel during the rod loading operation.

BWR final assembly

The BWR fuel assembly fixture recently installed in the Juzbado plant incorporates a standard automatism solution implemented by ENUSA in the last years, formed by a combination of state of the art computer, five axis CNC and standard bus PLC. By the development of a software on windows NT and C++ language the equipment is able to communicate in both ways with the main computer receiving fuel rod loading patterns, identifying the rod to be loaded after a bar code marking and routing the rod to its position through DC brushless motors driven by the CNC.

The equipment incorporates an interactive touch sensitive screen to make easier the dialogue with the operator.

PWR fuel assembly inspection

The fuel inspection covers 100% of manufacturing and the fixture is equipped with the latest generation of PLC and CNC without mechanical control elements, with a SCADA software in the local computer that is compatible with the central computer and with a specific inspection program for each type of fuel assembly. This characteristic enables to change the inspection pattern for each type of fuel assembly by means of the dialogue between the central computer and the local one what initiates the sequence to inspect the new type of fuel.

PILOT PLANTS

For development activities and new manufacturing processes, as well as new product preparation, ENUSA has

installed pilot plants apart from the manufacturing equipment. There are two pilot plants: one for pellet manufacturing and other for plugs welding and ultrasonic examination of the welds. These pilot plants enable to improve processes and to afford investigation projects, such as the segmented rods one, with the main aim of reaching higher burn-up fuel.

AUTOMATIC ROD HANDLING

ENUSA has developed a solution for automatic rod handling that has succeeded in increasing product quality, avoiding manual rod handling while maintaining at the same time U-channel trays and the actual equipment lay-out with a moderate investment.

The manufacturing process at Juzbado is discontinuous. Rods are transferred from one station to another in three types of U-channel trays.

At this moment the implementation has taken place in all rod processes and inspection areas for PWR and BWR, having reached the objective of eliminating manual rod handling and minimizing distortion during rod loading and unloading of U-channel trays.

This year a new lay-out has been implemented in the mechanical area,so that in the coming years a new automatic rod handling could be installed by means of direct horizontal transport of rods through the different stations, eliminating U-channel trays.
This new lay-out in addition to enabling the automatic rod handling will optimize the mechanical component flow (tubing, rods, and fuel assemblies).

COMPUTERIZED MANUFACTURING MANAGEMENT SYSTEMS

To automate the management of data ENUSA developed its own computer manufacturing system. This computer system, outweighing the difficulties of adapting W and GE approaches has applied the same solution, tailor made, to both products, PWR and BWR, manufacturing.

This system, known as PATMAN, encompasses all nuclear fuel fabrication from uranium oxide powder and components reception to fuel shipping documentation and has multiple advantages such as real-time information, process control, necessary primary materials, quality index, time reduction in pre-inventory and physical inventory phases, instant data transmission from technical offices to manufacturing lines and complete , rapid and reliable traceability. The system is able to transfer from Juzbado to the ENUSA Engineering Centre in Madrid the information about the plant manufacturing process and specifications, list of materials and other applicable documents in the other direction.

One of the applications of this program is the provision of the data required by Euratom, including the nuclear material inventory of the plant. This information can be provided approximately one hour after being requested. In fact Juzbado was the first European plant to automate this process in 1990 and to be able to send this information through the telephonic network under the JIIP compatible program developed by Euratom to support field inspections.

The project PATMAN manages the following areas:

- Nuclear Material Inventory
- Safeguards
- Manufacturing Data
- Quality Control (laboratory tests, non destructive inspection, etc...)
- UO_2 Powder and Components Reception
- Traceability (Manufacturing and Components)
- Shipping documentation
- Traceability and Control of gages and control instruments.

GAD PROJECT

ENUSA is installing a new Gad Rod Manufacturing area. This new project has obtained all the required regulatory authorizations, the necessary civil work within the main manufacturing building has been finished, the installation of the safety system has been completed and the mandatory prenuclear tests have been carried out.

At present the ceramic area processes qualification has started and the installation of rod manufacturing equipment is being completed.

This project was initiated at the beginning of 1992 and will be finished at the end of this year. The Gad Rod Manufacturing Line will be fully qualified in the next months and the production activities are programmed to start in 1995.

The equipment and facilities for the Gad Rod manufacturing are located in a new area inside the main manufacturing building with independent access of people and components from the rest of the ceramic area.

The plant will be able to process ADU or IDR powder and will produce PWR and BWR fuel rods. On the other hand this project has incorporated all the improvements developed in the recent years, both in systems, processes and equipment. This new Gad Rod manufacturing line includes all the required manufacturing equipment from UO_2 and Gd_2O_3 powder reception to GAD rod pressurization and seal weld.

As a part of the Gad Rod project a X-Ray fluorescence equipment has been installed to control the content and homogeneity of Gd_2O_3 in the UO_2 powder, as well as a magnetic and passive scanner to control at 100 % the Gd_2O_3 content, UO_2 enrichment, gaps, etc, in the finished Gad fuel rods.

To keep a total isolation from the UO_2 ceramic area, the new line has been designed with independent facilities. This new manufacturing area is equipped with separated ventilation and air conditioning system, waste treatment area and clothing change rooms so that it will be impossible to return material from the gadolinium area to the UO_2 ceramic area

CONCLUSIONS

Due to the development work the Juzbado Plant is able to supply technologically up-to-date diverse fuel of the highest quality:

- 17x17 AEF, with removable top nozzle, zircalloy grid (low pressure drop), debris bottom nozzle, controlled porosity pellet, with or without IFM (Intermediate Flow Mixer) and standard tubing with lengths from 12 to 14 feet.
- 14x14 Lo-Lopar and 15x15 which incorporates all technical advantages of 17x17 AEF.
- GE-11, rod matrix 9x 9, barrier, non barrier or triclad tubing, axial enrichment zones, anti-debris lower tie plates, partial length rods, large central water rods, and ferrule spacers.
- GE-12, rod matrix 10x10, incorporating all technical advantages of GE-11.

ENUSA currently supplies fuel, not only to the Spanish market but also to France, Belgium, Sweden, and Germany. ENUSA also takes part in R & D projects for the design and manufacturing of nuclear fuel. Among these projects, it is worth noting the segmented rod project developed to study the performance of different zirconium alloys, pellet designs, UO_2 conversion and pelletizing processes.