Hanns-Rudolf OESER
Director - Deutsche Gesellschaft
für Wiederaufarbeitung
von Kernbrennstoffen mbH

Femo-technique

La technique FEMO

Progrès pour le travail à distance et les téléinterventions

Le retraitement des combustibles nucléaires présente du génie chimique appliqué sous des conditions de haute activité c'est à dire des travaux effectués derrières des murs blindés.

La conception allemande pour la première usine commerciale en Allemagne prévoit des modules standards préfabriqués pour recevoir les équipements du procédé qui seront installés dans des cellules inertisées par de l'azote.

L' exploitation de l'usine s'effectue par du travail à distance, commandé d'une salle de contrôle. L'entretien se limite sur l'échange de petits composants ou de modules entières. Ces opération seront effectuées uniquement par téléintervention en utilisant des crues et des manipulateurs guidés par télévision.

Cette conception va être décrite ainsi que les experiences en échelle 1 : 1 dans un pilote.

FEMO-TECHNIQUE

A Milestone for Remote Operation and Maintenance

Reprocessing of spent nuclear fuel means chemical engineering in radioactive environment behind concrete walls.

The German concept for the first commercial reprocessing plant provides prefabricated standardized modules for the process equipment, which are installed in a huge nitrogen-blanketed cell. The process will be remotely operated from a central control-room.

Maintenance is limited to the exchange of small components or of complete modules, but will be done completely remote by means of cranes and manipulators guided by television.

The concept will be described and experiences from a 1 : 1 scale testing-facility will be given.

ɔ-TECHNIQUE

lestone for

ion and Maintenance

Oeser) *

nuclear power station, the nuclear fuel
ssile U^{235} and about half of the self-
the fuel has to be renewed. The energy produced has
as, namely 1 million kW-hours per 1 kg, whereas the quantity
waste produced is very small, namely only 4 %. The other 96 % of the spent
consist mainly of non-fissile U^{238}, but contain still sufficient fissile
and therefore valuable material to produce a further 30 % to 40 % of the
above mentioned energy, provided the spent fuel is reprocessed.

Reprocessing means to recover Uranium and Plutonium and to separate the radio
active waste for final disposal. This is achieved by a chemical process using
nitric acid to dissolve the spent fuel and an organic solvent to extract
U and Pu. The equipment for such a reprocessing plant looks very similar to
a conventional chemical plant and consists of extraction columns, vessels,
evaporators, heat-exchangers etc. and a confusing network of piping.

But different to conventional chemical processing the operation and mainte-
nance of a reprocessing plant is quite a problem, and this problem is the
high radiation, which makes the equipment not accessible for men.

Therefore, the equipment is behind thick concrete walls and locked into cells
If personnel has to enter, because direct maintenance becomes unavoidable, an
intervention is to be started: The equipment in the cell will be emptied and
rinsed, again and again, until the radiation has come down to a very low
level. Such decontamination needs time, and it can take weeks and weeks. In
addition, at least in Germany, there are stringent legal requirements, which
entitle the licensing-authority to approve such intervention only after
thorough and stepwise examination. This means in practice a lot of paperwork
and further delays. To give an example, the replacement of the small but one
and only fuel - dissolver in the German reprocessing pilot plant interrupted
the operation for 2 years. The pilot plant in Japan suffered a similar fate.

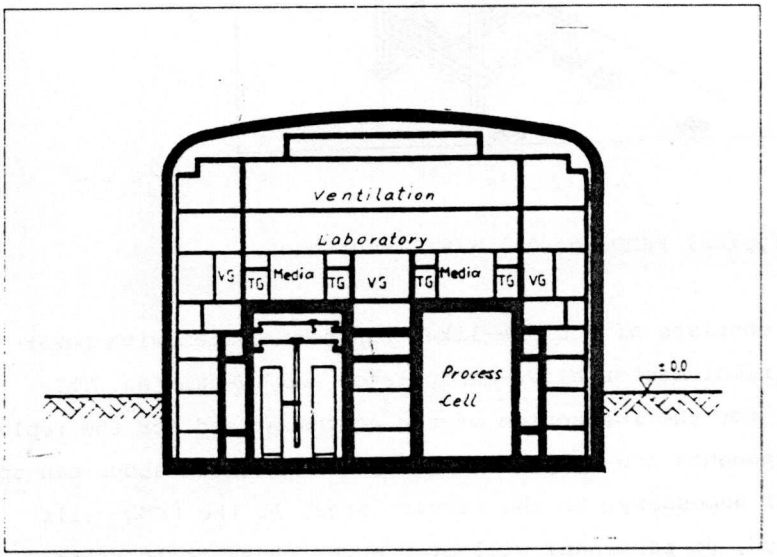
* DWK/Hannover (FRG)

A commercial plant cannot tolerate shut-downs of such duration. Therefore, the German concept for our first commercial plant takes a different approach:

Operation and maintenance of the high- and medium-active process will be completely remote.

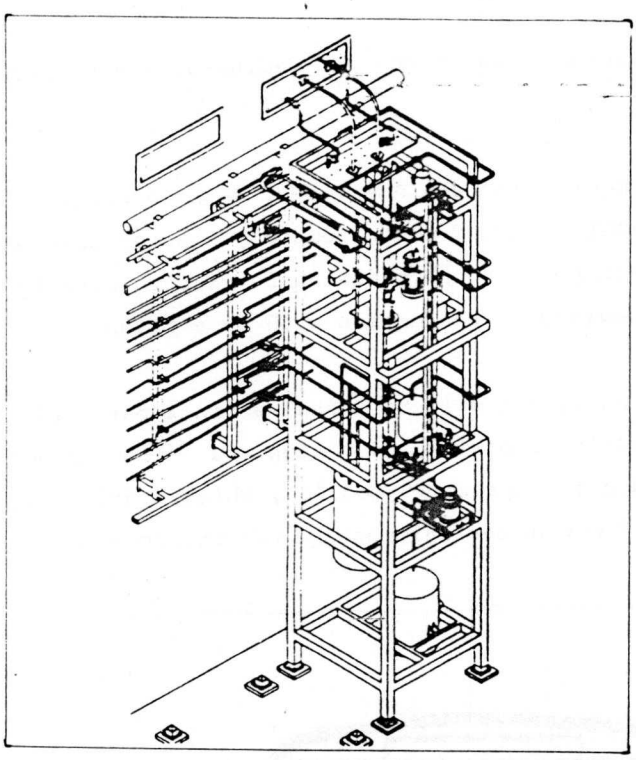
The basic idea was adapted from the Americans. We have called our design-philosophy "FEMO-TECHNIQUE". FEMO means remotely maintainable equipment-modules, where plant-inspection and maintenance will be done by remotely controlled handling devices in connection with television.

The chemical process equipment will be installed in 2 parallel cells of considerable size, namely 12 m wide, 24 m high and 70 to 90 m long. The equipment is subdivided in approx. 75 modules, which stand in 2 rows along the walls, leaving a 4 m wide central passage for transports.



cross-section of main-process-building

Steam, cooling water, electricity etc. are supplied through the wall. So-called jumpers form a removable connection from the wall to the head-plate of each module, from module to module or from the module to the pipe-curtain behind the modules. So-called exchange-components (pumps, control valves, instruments or other components, which are subject to tear and wear) are installed at the front-side of the module. All connecting flanges can be opened or locked with an impact wrench.



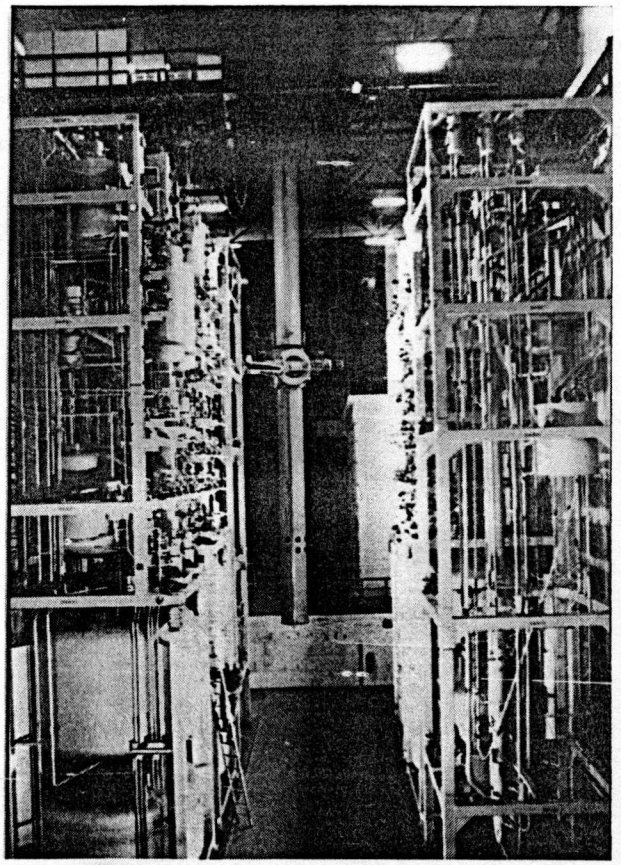
Typical FEMO-module w/wall-curtain

The handling-system consists of a crane-like transport system with power-manipulator or electrical master slave-manipulator and TV-cameras. This so-called MTS serves for the inspection of the equipment and for the replacement of exchange-components and jumpers. A heavy bridge-crane above can transpo a complete module, if necessary, to the service area. As the FEMO-cells are Nitrogen-blanketed, no personnel will ever enter these cells after operation has started.

Compared with the classical system of individual small cells and a big crane-hall above, the FEMO-system builds very compact. Platforms and staircases etc. inside the cells and intervention-cells fall completely away. The fully equipped modules come workshop-fabricated and -quality-controlled, this will save erection-time and costs. The building design is simple and not hampered by late process-alterations.

In accordance with American experience the operational availability will be high. Bottle-necks can be eliminated, if necessary, or better process steps can be introduced. Thus, plant-capacity could even be increased, if so needed in later years.

Right from the beginning of the FEMO-idea, we thought it necessary to build a 1 : 1 mock-up and to gain experience in remote design and remote handling. All fotos shown hereinafter are from our test-facility in Lahde near Hannover, where we can use the turbine hall of a former power station.



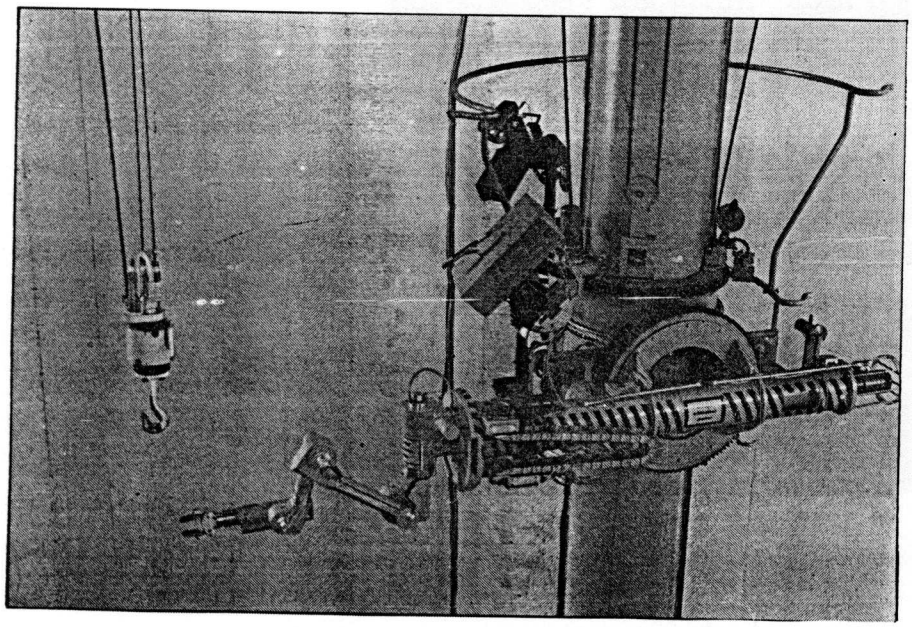
FEMO-mock-up in Lahde-test-facility

In 3 years, we have learnt a lot about module-design, handling of complete modules and exchange of jumpers and small components.

We have worked with crane-hook and impact wrench and were surprised, that this offers many advantages: The impact wrench hangs always in the horizontal or vertical position, and the operator sees the crane-rope moving, if his remote handling device touches some any object, so his control is easy, and he does not damage anything.

We have learnt, that viewing is most important. So far, the black and white TV-system has been superior to colour-TV and to stereo-systems. The light in the cell must not be too bright in order to avoid reflection. The zoom-effect of the TV-cameras produces excellent pictures from near-by, this makes inspection and precise handling easy.

Various manipulators have been tested with a first function-model of the future manipulator transport system (MTS). The exchange of small components and jumpers was successfully demonstrated, but the MTS handling system has still to be improved. The power manipulator used is relatively slow, and precise control needs experience.The high lifting-capacity of 200 kg leads to a rigid design of manipulator and MTS. On the other hand, some soft flexibility is required to avoid damage to the process-equipment. These contradicting requirements have still to be balanced.



Function model of MTS with power manipulator

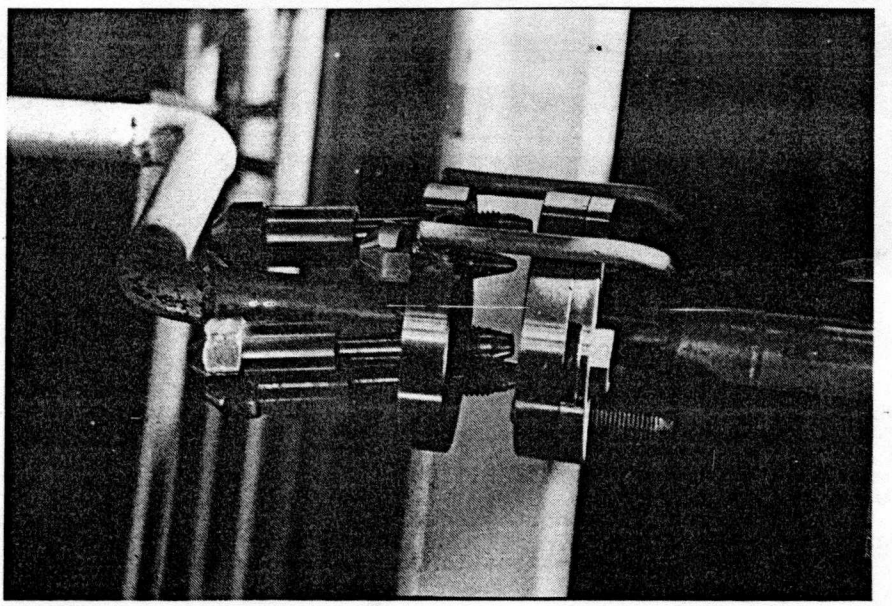
A new computer-controlled MTS is on the way, and automatic pre-positioning will be possible, before the operators take over. Another feature of the new MTS will be, that motors, gear-boxes, plugs, cable wheels and other components will be exchangeable with impact-wrench from a crane above. This prototype-MTS will be due at the end of this year.

FEMO-maintained components must be designed in a rigid way to enable remote handling by using crane-hook and impact-wrench only. For a remote assembly-work, 3 steps are normally to be followed (as an example, see jumper-flange on next foto):

(1) Coarse positioning: The crane-hook puts the jumper with its 2 fingers on the fixed flange (right side).

(2) Fine positioning: The crane-hook moves the jumper towards the fixed flange, until the conical guide-pin has entered into its corresponding opening. Both flanges are now face to face.

(3) Bolts tightening: The impact wrench tightens the bolts. The operator hears the strokes through the microphone, when the bolts are getting tight.

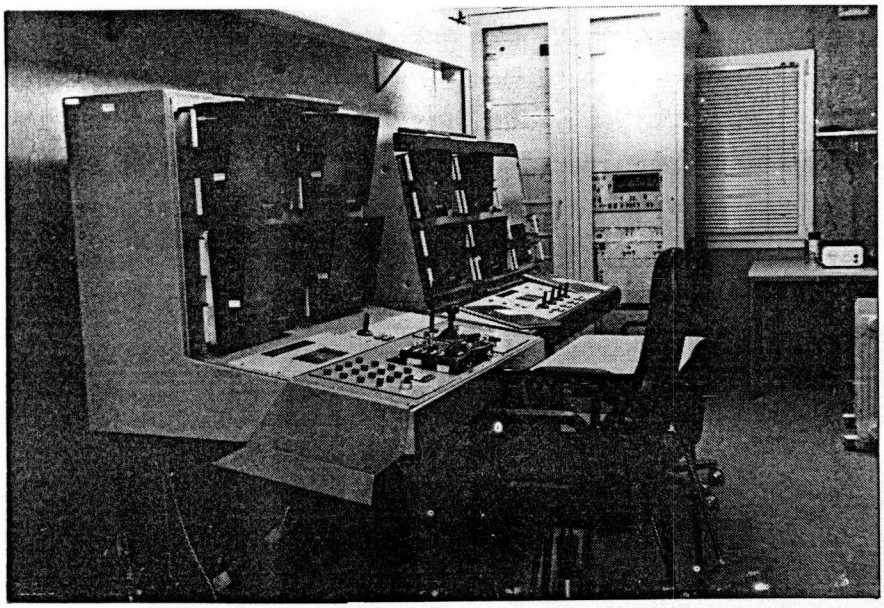


jumper with FEMO-flange

The procedure as described above takes about 15 to 20 minutes for one jumper.

To install a complete module with its 30 to 50 jumpers takes about 8 to 12 hours. To remove a complete module takes about the same time.

In the FEMO-control-room, always 2 operators are needed, one for TV-control and the other one to control the crane and handling devices. Both operators should be experienced craftsmen and need a good sense for 3dimensional imagination. To avoid stress, the work at the TV-screen is to be interrupted every hour and should not last longer than 4 hours altogether per day.



FEMO-control-room

After many thousand hours of remote handling at our testing-facility, the FEMO-technique has proven its reliability. Despite the rather simple installation, where we are still using the original cranes of the turbine hall, we have never experienced a no-go-situation or an unsolvable problem.

The FEMO-technique will play an important role in our reprocessing-plant, and we hope that other applications will come.

Hanns-Rudolf Oeser
Director

Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH
(DWK)
Hamburger Allee 4
D-3000 Hannover 1

0511 / 3390-601
(Phone)

9 22 020 DWK
(Telex)