A telerobot for the nuclear industry

The nuclear industry has not been a massive user of the industrial robot. AEA Technology hope to change that with NEATER, developed in cooperation with Staubli Unimation.

There has always been a high degree of emotion associated with the industrial robot. In the early seventies, when robotics started to be an accepted technology by industry, the 'selling' point was to replace people with robots. That some of these jobs were dirty and dangerous was often overlooked in the cry that robots were denying people work. More recently robots have become much more acceptable and have been sold for more humane reasons, such as increasing quality or performing precise repetitive functions which no human has ever been able to do. And, robots replacing people on boring and hazardous operations has become much more acceptable.

One of the most hazardous environments conceivable today is the nuclear industry and it would seem to be a natural for industrial robotics. But, the industrial robot has not found wide application in the industry. Much more in evidence is the telemanipulator in which tasks are performed under total human control through master-slave actuation. Here, the intelligence of the human operator is being utilised to perform complex manipulative tasks. However, within these complex tasks are many mundane ones in which an unintelligent industrial robot would be quite at home.

But there are many disadvantages of using industrial robots, or 'fixed envelope manipulators', to quote Ed Abel of the Remote Handling and Robotics group of Harwell Laboratories, a part of the UKAEA Technology. In a presentation to the 1989 IEEE Nuclear Science symposium in San Francisco last year* Abel argued that 'wall or mast-mounted manipulators provide improved volume coverage', as compared to fixed envelope manipulators. But, the high cost and reliability of the former have prevented their widespread use. On the other hand, electrically driven industrial robots have been around for a long time, are well proven and consequently reliable and relatively cheap.

The requirement, it would appear, is an integration of the two technologies referred to as telerobotics, which Abel defines as a combination of industrial robot technology and the skills of a human operator. Telerobotics deals with unstructured environments, such as those met in nuclear remote handling, whereas industrial robotics is concerned primarily with structured environments. This 'insensitivity' to the unexpected, together with a limited work envelope compared to a manipulator, is a disadvantage for the industrial robot in nuclear applications. However, providing a skilled operator with the means of gaining direct access to an industrial robot's controller, and not detracting from its cost effectiveness and reliability, would, in Abel's view, create a true telerobot. And, that is exactly how NEATER (Nuclear Engineered Advanced TEle Robot), the first telerobot was devised.

NEATER was the result of a joint development between AEA Technology, the trading arm of the UK Atomic Energy Authority, with funding from the UK Department of Energy. The efforts of this project came to fruition last December when Anthony Staubli, president of Staubli International, handed over the British-built NEATER robot to John Collier, the UKAEA chairman.

There has clearly been a 'meeting of minds' in the concept and development of this unique robot. At the handing over ceremony Staubli explained how the idea of a nuclear industry robot had

John Collier (right), chairman of UK Atomic Energy Authority, accepts the keys of the first NEATER robot from Anthony Staubli, president of Staubli International.

*'Telerobotics and 3-D TV – what you need to know', by E Abel – *Proc. 1989 IEEE Nuclear Science Symposium*, 25-27 October 1989, San Francisco, USA.

NEATER has been designed for easy maintenance.

been conceived by Staubli Unimation through the success of the clean room version of its PUMA robot. Clean room robotics has proved to be a successful niche market for the robot company. As a result, some two years ago it identified the nuclear industry as offering a new opportunity for the clean room PUMAs, particularly in waste management and decommissioning applications.

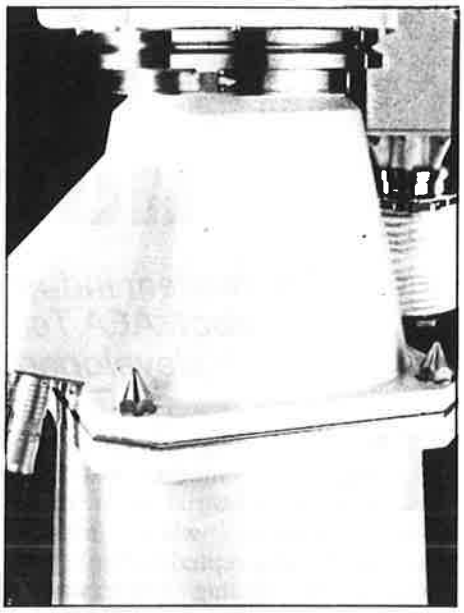
Also, at that time the UKAEA was a user of standard PUMAs at Harwell, Risley and Sellafield. Its experience of industrial robots, particularly at Harwell, and its thinking on the development of telerobotic devices led to it entering into discussions with Staubli Unimation. Ed Abel, now business development manager at AEA Technology, comments favourably on the co-operation shown by the robot manufacturer in developing NEATER. He told *The Industrial Robot*, 'When the project started we examined several well-known robots, but went for the PUMA because Staubli Unimation were so open with information about the controller, and we needed that data to be able to interface our teleoperator controller to the robot's. Also, the proximity of the Unimation operation in Telford was a strong factor in furthering the work, particularly because of its control expertise'. This expertise comes from the fact that the VAL controller was developed and built in Telford.

The nuclear engineering design of NEATER was undertaken by AEA's Harwell Laboratory and implemented by Staubli Unimation at Telford. NEATER is based on the clean room version of the PUMA 762 robot. Harwell re-engineered the device for use by the nuclear industry in radioactive decommissioning work. It is designed for easy maintenance and to be tolerant of a typical radiation environment.

There are a number of areas that have been worked on to endow the robot with radiation-tolerant properties. First, it has double seals on all axes and the covers are protected against the ingress of contamination. Each axis is protected either by an extra grease filled labyrinth seal or, at the wrist, by a gaiter.

Much care was taken in meeting the maintenance requirements as this function needs to be performed remotely in nuclear work. Thus, the design is such that the outer link or forearm can be removed as a complete unit. Also, the base has been reduced in size and can be split to reduce the total weight of the individual parts. All bolts and fixing are designed to be easily tightened or removed using conventional or remote handling techniques, such as master-slave manipulators or through hands-on maintenance in pressurised suits. The surfaces have a smooth finish and cracks and crevices are avoided to minimise contamination build-up.

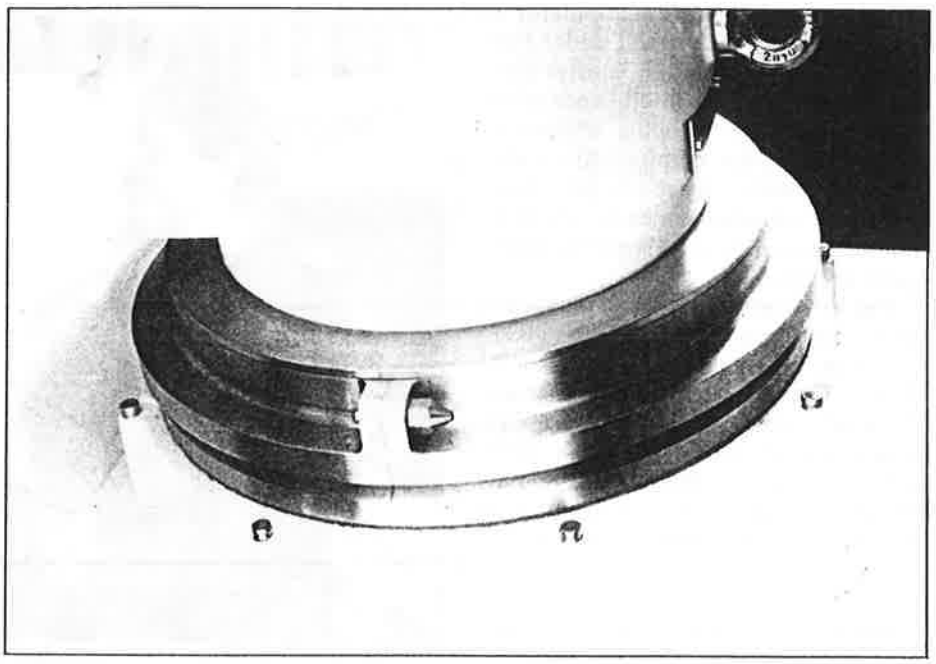
An exercise was also undertaken to examine the irradiation properties of



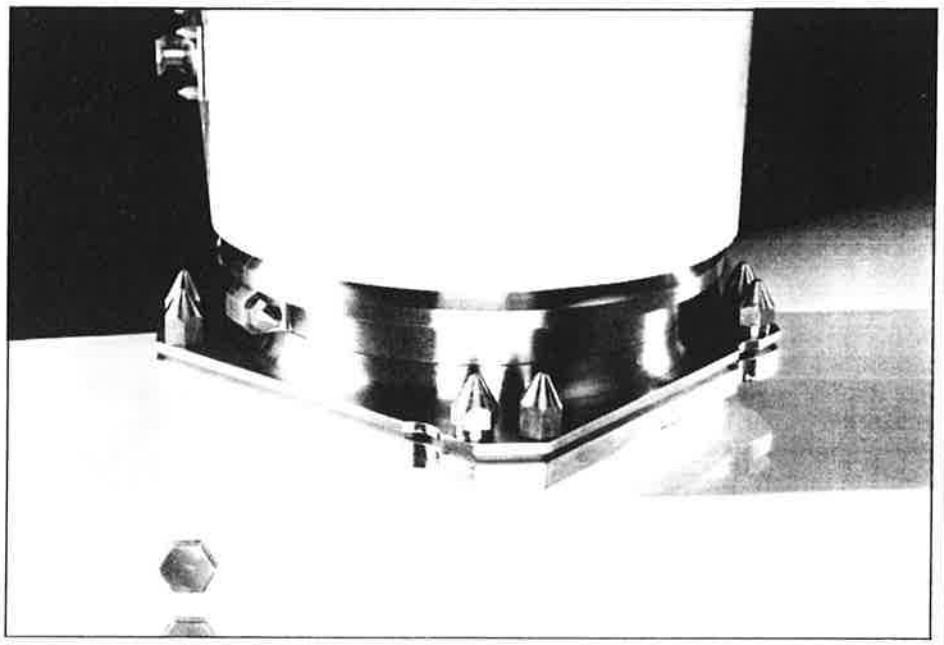
The base of the nuclear robot can be split for easy handling.

internal elements, such as wiring connectors and bearings. Where necessary these were replaced by radiation tolerant alternatives. As a result it is anticipated that the robot will be able to tolerate an integrated dose of 10^6 GY before a major overhaul has to be undertaken.

NEATER can operate in a pure robotic mode using the PUMA's standard VAL controller and software. It can be programmed through the standard teach pendant or from an off-line programming system. Or, it can



Labyrinth seals are used on all of the major joints of NEATER.



Stainless steel and smooth surfaces are designed to minimise contamination build-up.

operate as a telerobot in a remote control mode via television using the Harwell Input Controller.

In the latter mode the operator controls the robot's motions using joy sticks or a simple six degree-of-freedom input device. The Harwell Controller checks the demands from the joy stick or input device so that the instructions can be passed directly to the VAL II controller without the operator having to worry about the robot stalling or tripping out if excessive demands are made.

Abel believes that the advanced nature of the VAL II controller was very significant in dealing with this problem. He comments, 'It was relatively easy to interface to the VAL controller, as, unlike many robot manufacturers' systems, the Unimation controller drives all six axes virtually simultaneously'.

The Harwell Controller uses a Research Machines VX-20 computer with an 80386 microprocessor and 80387 co-processor to calculate robot kinematics and manage singularities and joint constraints. Harwell is constantly developing new software algorithms to allow for easy surface following, stand-off dominant or ranked degrees of freedom – for drilling and cutting – and for trajectory generation and control.

The nuclear robot is likely to be used primarily for decommissioning and waste management application. In receiving the robot Collier commented, 'One of the reasons for the high cost of nuclear power generated in Magnox stations is waste management and decommissioning, and NEATER should allow these to be reduced. It is an important development that will be welcomed by Nuclear Electric'.

NEATER is not meant to replace through the wall master-slave manipulators because of its shape and weight. However, it can be used either as a robot or as a telerobot and, therefore, is suitable for a spectrum of applications, from the well structured to the totally unstructured and unpredictable. With other developments in nuclear remote handling, such as radiation tolerant 3-D TV, the robot can be used to tackle complex tasks requiring teleoperation with the confidence that comes from precise control over position orientation and speed of movement. And, without the penalty of high cost or long development time scales.

Some of the tasks for which the device is claimed to be suitable include fuel fabrication, filter changing, waste drum handling, posting and bagging operations, as well as routine manipulation and tool deployment.

Both Staubli Unimation and Harwell are confident that NEATER has a promising commercial future. Marketing and systems will be the responsibility of AEA Technology, and specifically Ed Abel. He comments, 'The result (of the development) has been an extremely cost effective alternative to having to develop special purpose equipment with the boldness that NEATER is very well placed to capture world-wide sales'. And, with Staubli Unimation's French connections and the high degree of nuclear power generation in that country, there would seem to be a natural market for the robot. □

Harwell's NEATER telerobot team (from left to right); Dr Ed Abel – NEATER business development manager, John Phillpott – head of Engineering Science division, Dr Chris Watson – head of Remote Handling and Robotics group, and Trevor Hanna – NEATER project manager.