TELEMANIPULATORS - ENHANCING YESTERDAY'S TECHNOLOGY TO PERFORM TODAY'S TASKS

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ABSTRACT

A telemanipulator is a device which, through electronic, hydraulic, or mechanical linkages, allows a hand-like mechanism to be controlled by a human operator. The purpose of such a device is usually to move or manipulate hazardous materials for reasons of safety.

According to Joseph Schumpeter, creative destruction describes the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one". In the same manner, remote handling technology has improved in the last decades.
Mechanical design improvements, complex robotic functions and force feedback are examples of progress in the sector.

New challenges in the nuclear industry influence tasks performed in hot cells. This evolution raised key questions: How can hot cells be used on a long-term basis and how can improvements be integrated at lower costs to increase the cost effectiveness?

This paper will concentrate on the upgrade of remote handling technics in existing through-wall tubes with electrical driven manipulators and the impact on new planning. It will be divided as following:

1. Short presentation of Wälischmiller and replacing the old with new
2. Upgrade of telemanipulators with electrical driven manipulators
3. Installation of new electrical driven power manipulators in liner tubes for telemanipulators
4. Conclusion

About Wälischmiller: Wälischmiller Engineering has been providing safe, smart and cost-effective remote handling solutions with the famed German quality and reliability for over 60 years worldwide. Our handling systems offer various mechanical telemanipulators for a wide range of applications, our models A100 and A200 series were successfully employed in Sellafield, Cadarache and Chernobyl. Other products include remote controlled power manipulators from the A1000 series for handling heavy loads; intervention systems with servo-manipulators for repair and maintenance tasks in hazardous and inaccessible zones as well as remote-controlled and automatic equipment for positioning, transport and sampling tasks.

1. Introduction

1.1. What does Wälischmiller do?

Wälischmiller Engineering is a German company which has been providing safe, smart and cost-effective remote handling solutions with the famed German quality and reliability for over 60 years worldwide.

Wälischmiller Engineering specializes in manufacturing remote-handling systems, radiation protection equipment and robotics for hazardous environments for application in nuclear and chemical industries. Our work includes projects in the most difficult nuclear environments including, Sellafield, Rokkasho and Chernobyl.

Wälischmiller has a hard earned international reputation for performance, excellence in engineering and exceptional robotic hardware. In the most difficult and challenging nuclear environments, Wälischmiller has demonstrated the ability to bring solutions and success to many of the most difficult high-radiation remediation challenges.

Our handling systems offer various mechanical telemanipulators for a wide range of applications, our models A100 and A200 series were successfully employed in Sellafield, Cadarache and Chernobyl. Other products include remote-controlled power manipulators from the A1000 series for handling heavy loads; intervention systems with servo-manipulators for repair and maintenance tasks in hazardous and inaccessible zones as well as remote-controlled and automatic equipment for positioning, transport and sampling tasks.

Our special TELBOT® robot is a multi-functional, modular and automatic system with unique capabilities which includes unlimited rotation in all axes, no wiring inside or outside the Telbot arm, and unlimited fast and precise movement which made TELBOT® the star of clean-up operations. TELBOT® systems have been successfully employed in Rokkasho vitrification plants and for decommissioning power plants in Rheinsberg and Greifswald.

At Wälischmiller Engineering we take pride in offering turnkey solutions. We provide a fully integrated service that extends from planning and product development all the way to manufacturing, installation and service.

By working closely with our specialist engineers and project managers, you can be confident of receiving not just an off-the shelf product, but a custom-tailored solution to your remote handling challenges; that offers the highest quality and guarantee of long-term operational safety to even the most-demanding customers.

Our quality management system has been certified to DIN EN ISO 9001:2008 and the KTA 1401 safety standard of the Nuclear Safety Standards Commission.

1.2. Replacing the old with new

Famed economist Joseph Schumpeter summarizes that “Creative Destruction” is described as the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one".

In the same manner, remote handling technology has advanced in the last decades. Mechanical design improvements, complex robotic functions and force feedback are examples of progress in the sector.

New challenges in the nuclear industry influence tasks performed in hot cells. This evolution raised key questions: How can hot cells be used on a long-term basis and how can functional improvements be integrated at lower costs to increase the cost effectiveness? This question will be answered by explaining new developments in remote handling technologies.

2. Upgrade of telemanipulators with electrical driven manipulators.

2.1. Principle

A telemanipulator is a device which, through electronic, hydraulic, or mechanical linkages, allows a hand-like mechanism to be controlled by a human operator. This paragraph covers mechanical telemanipulators composed of three units: a cold arm (master), a through-wall tube and a hot arm (slave). The mechanical movements of the telemanipulators are completed with electric pre-positioning of the X, Y and Z axes. The electric movements facilitate access to working areas that are remote or difficult to reach.

Mechanical telemanipulators are available in a variety of different and combinable versions, for example single or double-telescoping, with dynamic weight counterbalance or with gas-tight or non-gas-tight through-wall tubes. The division into three parts simplifies assembly and dismantling of the manipulator. This advantage is used to modify the system to a fully electrically driven telemanipulator.

Electrically driven manipulators are composed of a drive unit with servo motors that can be mounted directly on the slave-arm or on the through-wall tube of a telescopic telemanipulator. (Fig. 1. Servo-Manipulator HWM A100S)

Electrically driven telemanipulators allow operators to drive the telemanipulator systems they are accustomed via an operator console. The advantage is that the capacities can be increased and the operator fatigue minimised.

Fig. 1. Servo-Manipulator HWM A100S with drive unit on the through-wall tube and controlled by JOYARM

2.2. Complex operating systems for electrically driven telemanipulators

Electrically driven telemanipulators can be controlled via operating control stations with joint by joint movements using knobs, push buttons, and simple joysticks (Fig. 2. Control Unit with Joysticks). In its most elaborated version, it can be controlled via master-arms, which allow controlled synchronisation with the manipulator: master-arm movements are copied 1:1 to the telemanipulator. Now with one device, similar to the JOYARM, operators can realise precise motion control and then switch to the intuitive quick positioning offered by master-slave control systems (Fig. 3. JOYARM II).

Fig. 2. Control Unit with Joysticks

Fig. 3. JOYARM II

In some cases, work includes repeated access routes or fixed access points that the manipulator arm has to pass repeatedly. For example a fixed point where the waste materials are collected, or a repeated transport route that the arm has to go along for each step. Electrically driven manipulators can be equipped with a Cartesian coordinate frame offering the telemanipulator a robotic function. Based on this function, Wälischmiller Engineering has developed the “GoTo-Mode”. The GoTo-Mode is a "teach and playback mode" which has been developed especially for remotely operated manipulators. Quick direct teach, quick play function and an intuitive touch-panel layout are some of the features. With the GoTo-Mode high working efficiency has been achieved.

These advancements bring advantages to the operators. The work can take place in a secure area with a controller and a visualisation system.
Also, the easy connection / disconnection of the system are an advantage. One drive unit can be allocated to several slave-arms, when they are note in use. With one system, several telemanipulators can be operated from one central place, like a control room.
The inverse Kinematic control algorithms now allow users to control the manipulator in varied frameworks – Cartesian, spherical, cylindrical or joint by joint. The Position feedback allows the user to teach and repeat sensitive moves and program hard and soft keep out zones for the manipulator. The productivity is increased and the fatigue of the operators is reduced.

These electrical driven telemanipulators are limited in handling capacity. Also, improvements in power manipulators make it possible to introduce them in liner tubes, replacing mechanical telemanipulators.

3. Installation of new electrical driven power manipulators in liner tubes for telemanipulators

Mature technologies allow for power manipulators to be inserted through existing hot cell penetrations.

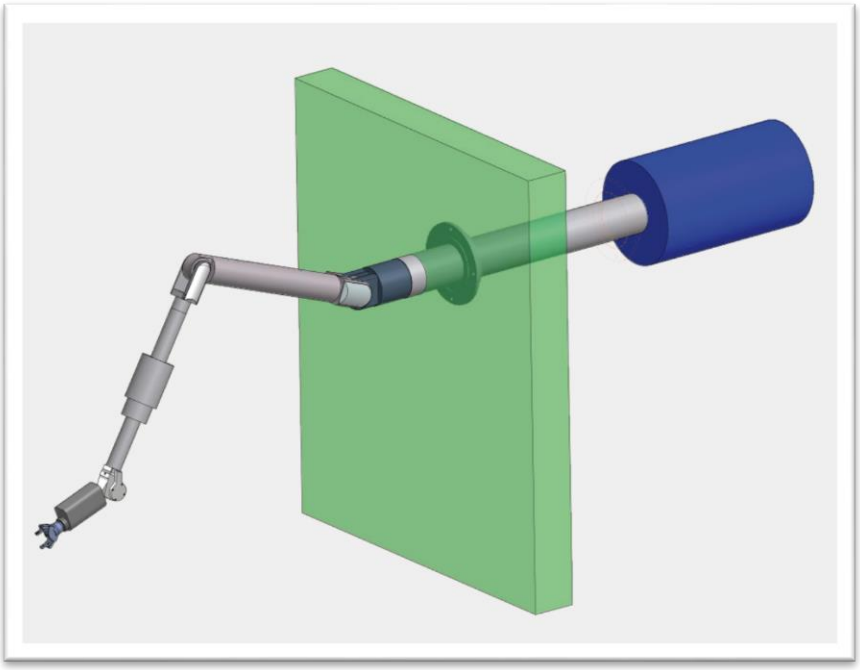

Fig. 4. 3-D Model of a power manipulator installed in a liner tube

3.1. Improvement of power manipulators

Power manipulators are specialized machines with numerous fields of application. Therefore they are often modular systems which can be customised. The range of movements is designed so as to access any point within the designated area of a hot cell.

Developments in radiation hardening of electrical drives have allowed power manipulators to be rated to $1x10^6$ Gy total dose. The size reduction and the improvement of drive units allow an installation in confined spaces. The production volumes have allowed for the incorporation of lessons learned and true reliability and robustness features. The use of radiation hardened position feedback hardware has enabled controls enhancements.

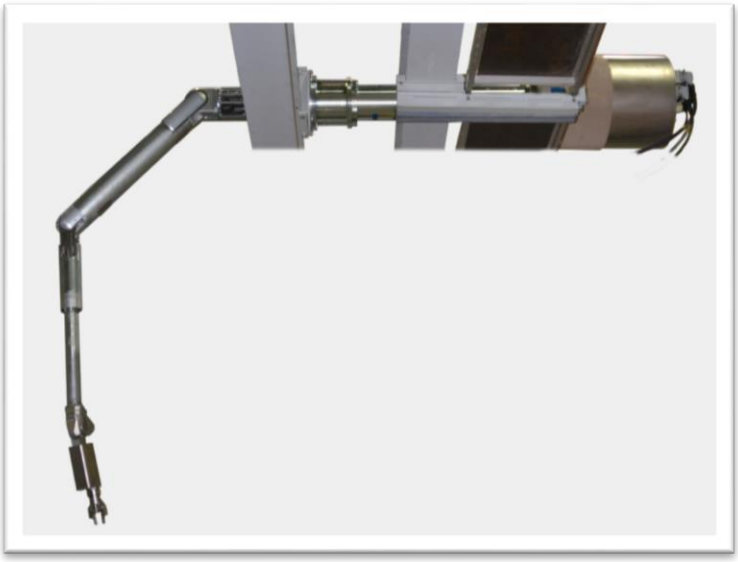

Fig. 5. Power Manipulator with standard components as 3-D Model before installed in a through-wall tube

The improvements in components and software enable the adaptation of power manipulators in order to integrate robotic functions. In this case, control units like master arms and JOYARM can be used.

Due to these improvements, power manipulators can be installed in a liner tube as replacement of mechanical telemanipulators and offer the advantages in user-friendly operation and increase of operator's safety. The standards opening are 10' (254 cm) and 11' (270 cm). In some cases to increase the handling capacity the opening has to be enlarged.

Hydraulic power manipulators can also be installed in liner tubes. Hydraulics systems use fluids to transfer energy from one location to another. They are more adapted for rough works where precision is not required. Electrical power manipulators can be driven smoothly and precisely with steplessly variable speeds.

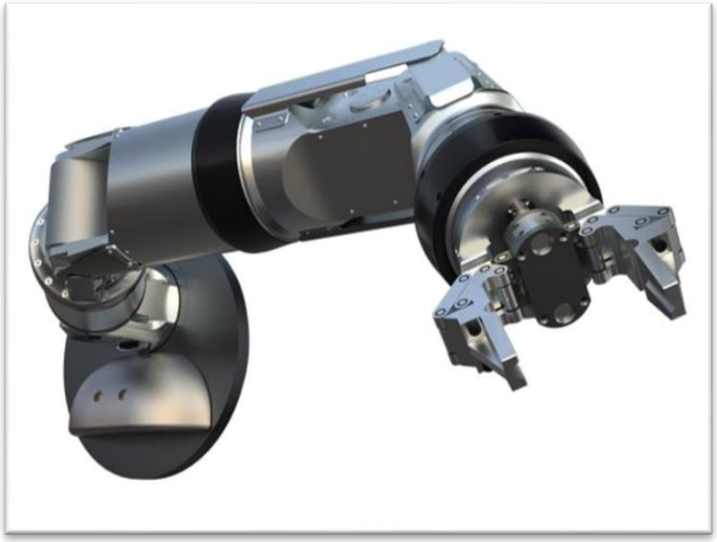

Fig. 6. Hydraulic Manipulator

Hydraulics will leak fluid. Loss of fluid leads to less efficiency. Hydraulic fluid leaks lead to cleanliness problems and potential damage to surrounding components and areas. Hydraulic actuators require many companion parts, including a fluid reservoir, motors, pumps, release

valves, and heat exchangers, along with noise-reduction equipment. In contrary to electrical systems, this makes for linear motions systems that are large and difficult to accommodate.

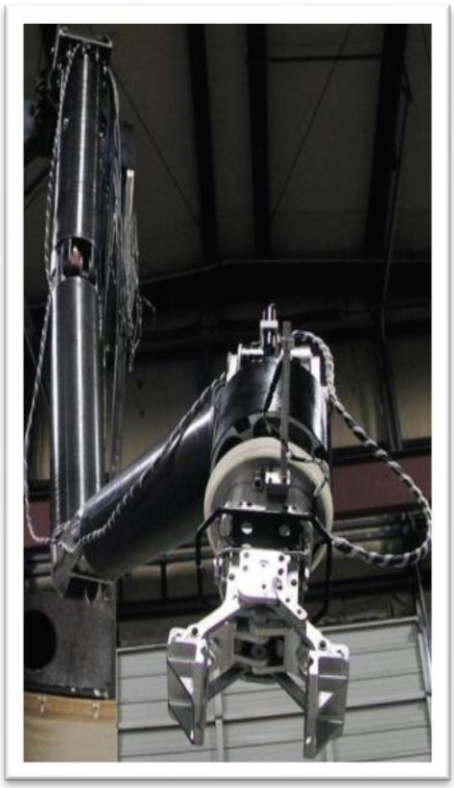

Fig. 7. Hydraulic Manipulator

The advancement in drive mechanisms have allowed for the removal of drives and gearboxes out of high dose areas.

3.2. Robot System TELBOT®

The TELBOT® is a modular robot with selectable drives, arm lengths and joint modules. The motors and gears are located in a base behind the arm. Movements are effected by concentric tubes inside the arm links and concentric bevel gears inside the joints. Consequently, there is no wiring either inside or outside the arm and all axes can rotate freely. The TELBOT® takes advantage of these features and is therefore suitable to be installed in liner tubes.

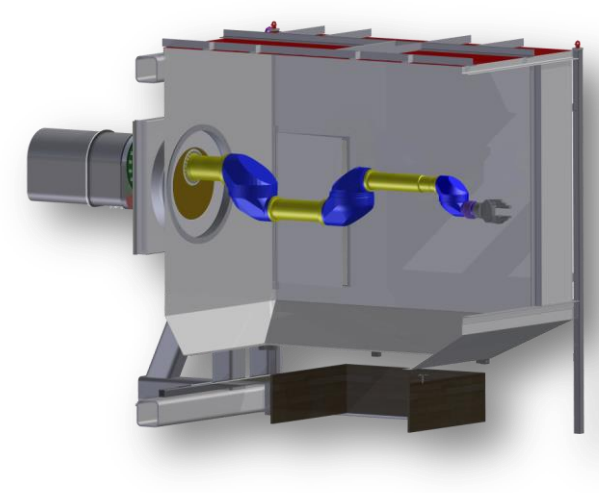

Fig. 1. 3-D Model of TELBOT installed in a box

Fig. 8. TELBOT installed in a liner tube

Sleek construction and high dexterity enable the TELBOT® to access confined spaces. It can be operated with various control stations:

- Joint by joint movements using knobs, push buttons, and simple joysticks
- Master-arm, which allow controlled synchronization with the manipulator: Master-arm movements are copied 1:1 to the manipulator
- Now with the JOYARM, operators can realize precise motion control and then switch to the intuitive quick positioning offered by master-slave control systems

Fig. 9. TELBOT® and Master Arm

4. Conclusion

As shown through this paper, the march of “Creative Destruction” goes on in the field of remote handling and robotics. It can be seen clearly in the growth and maturity of our ability to “teach an old manipulator new tricks”. More than ever, the budgets available to solve huge remote handling challenges like the Hanford Tanks and the Sellafield Ponds & Silos are constrained. By developing technology which allows a vendor to use an older remote handling equipment for a new task; or achieve great cost and time savings on a current project; is a game changer. The concept of one arm servicing multiple hot cells is essential.

In addition, this “creative destruction” forces us to expand the current markets for our innovations beyond the nuclear arena. An example is our development of a version of our radiation hardened TELBOT® robot to meet a specific necessity of the offshore oil and gas industry. The TELBOT®, which has been delivered, is the only worldwide robot which is certified ATEX category 1 zone 0. The robot is equipped with a camera for inspection and a high pressure wash lance. The wash lance is installed in the arm parts. It means that no wiring or water tubes are outside of the arm. The TELBOT® will achieve tank inspection and cleaning. This task has to be performed remotely and given the explosive environment, our TELBOT® had to function in a whole new way. Projects like this drive us far from our nuclear roots, but clearly show the technical adaptability of a sophisticated machine moving from one hazardous environment to another.

But our real near-term challenges lie in the places we know best. The easy part of decommissioning the WWII weapons complex has been nearly completed; Places like Hanford, Oak Ridge, Savannah River and Los Alamos and at sites across the UK and Europe. Lots of buildings knocked down and percent wise, great strides. But what is left is the hard part. Many very difficult remediation challenges that will require the next generation of remote handling and robotics to achieve success.

The Americans have a saying, “Necessity is the mother of Invention”. Throughout history, this has held true. Now in our technology driven world we must address challenges successfully over the long term, remote handling and robotics must be employed. The necessity to keep personnel exposures as low as achievable dictates the increased use of remote handling.

The retrieval, transport, reprocessing and ultimate disposal of radioactive material, from the most difficult locations is the hard part and must employ remote solutions to protect the work force and the environment. The solutions to these programs must me rugged, reliable, and nimble and be a work horse over a long remediation schedule.

Products continue to improve to meet customers’ needs and will continue to look for “creative destruction”. As we enter the next stages of decommissioning in both the commercial and government arenas; we must look for new solutions and equipment that meet the precise need of the situation and protect the workers and the environment in new and effective ways. Wälischmiller has always been at the forefront of remote handling and robotic innovation and we plan to stay there. Thank You!!