

The robotized field operator

Greater safety and productivity by design
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The aim, in almost all industries, is to have a high level of automation to increase productivity and efficiency. Industrial robots, which have been one important technology enabler in achieving this aim, are designed to perform repetitive, heavy, dirty and dangerous tasks. Within the oil and gas industry, robots have been used in very specific niche applications where the main driver has been safety, but this trend is now changing. Oil and gas companies have started to explore broader applications where robots may also have a positive impact on productivity and efficiency. One such application is the remote operation of oil and gas fields, particularly those in hazardous environments. ABB is a leading manufacturer of robots and is committed to developing “robotized field operators” for the oil and gas industry.



An orange robot moves around the process site and performs a combination of routine inspections and replaces a safety valve. This robot works along side two others. All three are supervised by a human operator located hundreds of miles away in the process control center. The human supervisor has defined and initiated the maintenance tasks in response to a condition-based monitoring (CBM) report generated by the automation system. With overall responsibility for safety, the operator instructs the automation system to reschedule the sub-tasks. Using the 3-D camera mounted on one of the robots, the operator inspects the machinery and identifies further components that require removal and replacement.

Frequently, robots are used to carry out repetitive routine tasks, which may be heavy, dirty, remote, dangerous or otherwise better suited to a robot than a human.

Although this scene is set sometime in the future, it is not far from reality. Some aspects of it are already happening in space and deep beneath the oceans, where tasks cannot easily be performed by humans. The scenario shows how robotics technology could be taken a step further and moved into oil and gas facilities to improve health, safety and the environment (HSE) and to increase productivity.

Trends in oil and gas

The oil and gas industries are facing a number of challenges that require novel technical solutions and business models. The world's energy consumption is growing and although alternative energy sources are currently expanding, there remains a high demand for oil and gas. However, recovering oil and gas from existing reservoirs and new fields has become more chal-

lenging with reduced profit margins. Many of the more accessible oil and gas fields have already been exploited, leaving the more remote and technically challenging reserves for future exploration. Furthermore, experienced crew are fast approaching retirement age, which means that fewer experienced workers will be available to extract these reserves. Based on the expectation of continuous market growth, the trend will be for stronger cuts in costs and increased energy efficiency. These trends suggest there will be increased investments in new solutions and business models to build on the existing infrastructure and also to develop new oil and gas fields. To successfully meet these goals, the oil and gas industry is prepared to change working practices and adapt their infrastructure.

Collaboration is recognized by the industry as an essential element to achieve the efficient and safe operation of their industrial processes. In many cases, the collaboration takes place over a distance, for example, between the control room and a remotely located expert or field operator **1**. Integrated Operations¹⁾ (IO) (also known as eField, iField, Smart-

Field, etc) is a broad philosophy that aims to tackle the overriding challenges faced by the industry. The IO idea attempts to achieve goals through a combination of new methods focusing on the latest developments in technology and work processes.

Robotics business and markets

The use of robotics technology has made a large impact in many industries, particularly in the manufacturing area. Efficiency and productivity remain the main incentives for industries to use robots to automate their manufacturing processes. Most often, particularly in manufacturing plants, robots are used to carry out repetitive routine tasks, which may be heavy, dirty, remote, dangerous or otherwise better suited to a robot than a human. Also, these tasks typically require very high reliability and accuracy for which industrial robots are designed.

The automotive industry has had a major influence on the development of industrial robots. The principal goals of the car manufacturing industry are to increase productivity, flexibility, reliability and product quality at a lower cost. These business aims have pushed manpower away from

1 ABB-Shell collaboration room – an example of an integrated operations center



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¹⁾ Integrated Operations (IO): StatoilHydro defines IO as "collaboration across disciplines, companies, organizational and geographical boundaries, made possible by real-time data and new work processes, in order to reach safer and better decisions – faster." To help identify the methods, technologies and work processes necessary to integrate its operations, StatoilHydro appointed an R&D consortium consisting of ABB, IBM, SKF and Aker Solutions. One of the seven sub-projects concentrates on robotics technology to supplement and extend human inspection and intervention capabilities at topside and onshore facilities. The objective is to develop solutions that combine tele-robotics and advanced visualization to enable remotely operated inspection and maintenance operations, as well as to identify and close technology gaps.

Productivity solutions

the production lines in favor of robots. Robotic production facilities are largely fully automated and run 24 hours a day seven days a week (24/7). Robots handle everything from sheet metal cutting, assembly and welding to painting, coating and general material handling **2**. Robot manipulators are typically developed to handle one specific task and have even, in some cases, been developed particularly for a certain application such as to open and close car doors.

When automating a manufacturing plant with robotics technology, the greatest impact can be made when the entire process from start to finish is redesigned, rather than when only individual processes are automated.

A higher degree of automation naturally implies changes in technology, peoples' work patterns and organization. Although robotic systems can carry out repetitive, heavy and dirty jobs, they can rarely operate entirely without human intervention. Operators are required to monitor and control their operations and hence, they become an integrated part of the control loop and the receivers of the robot's output. Naturally an increased degree of automation results in job description changes so that personnel with different competences, such as planning, programming and maintenance, are required to maintain productivity. A critical component to

successfully implement automated processes within a manufacturing plant is to be prepared and plan for such organizational changes by updating job descriptions, roles and responsibilities to suit the reorganization.

A higher degree of automation requires changes in technology, peoples' work patterns and organization.

Robotics for oil and gas

The use of robots in the oil and gas industry has been limited. The industry has generally only automated processes that are either difficult or impossible for people to perform, or that would dramatically improve HSE issues. Examples of such applications are found in subsea facilities and pipeline inspections, in the automation of drilling operations, well tractors and in special inspection applications. Very often, the industry has experienced a negative impact on productivity with automation, running counter to the general goal of automation. This trend, however, is now changing. Today, the oil and gas business sees robotic technology as an enabler to increase efficiency, productivity and to improve HSE issues. The oil and gas extraction processes are generally dangerous and risky. Off-

shore facilities operate in rough seas and all kinds of weather conditions. In addition, hazardous environments are encountered, for example those with high concentrations of dangerous gases, such as hydrogen sulphide (H₂S). The use of robots in such environments has the potential to reduce human exposure to hazards. They are designed and manufactured to operate reliably 24/7 and can be designed to cope flexibly with a range of operations. With greater demands for energy and the increasing difficulty experienced by the industry to extract oil and gas economically, it is clear that the oil and gas industry will have to change its strategy and think afresh, especially if it is to successfully extract tail-end production from existing sites and exploit the smaller more marginal oil and gas fields of the future.

There are two broad areas in which robots can be used for oil and gas: those applications that demand completely new robot designs and those in which existing industrial robots can be applied. The further development of subsea oil and gas production relies heavily on remotely operated vehicles (ROVs). These are used for exploration, inspection and interaction with the process structures. Such applications are unique to the oil and

2 ABB robot spray painting in an automotive production facility



3 ABB robot at work performing routine inspection of process equipment



gas industry and require completely new robot designs.

Robots in the oil and gas industry would be expected to perform inspection and operational tasks to maintain the process infrastructure.

Other applications show clear similarities to manufacturing processes, where robots have already been deployed to carry out repetitive tasks and where this increased automation has already produced benefits. However, the characteristics of the tasks in the oil and gas industry differ from conventional manufacturing processes. Robots in the oil and gas industry would be expected to perform inspection and operational tasks to maintain the process infrastructure ³. This means that the robot would have more than one task and not all tasks could be predicted. Furthermore, offshore topside²⁾ facilities would have to be redesigned, since space is restricted, so that robots could move around and access the process equipment. The design of such automated topside facilities focuses on existing industrial robots, with minor modification, so that applications for the oil and gas industry can be performed successfully in harsh environments. This application is recognized as a “game changer” for the oil and gas segment.

Challenges for oil and gas robotics

Robotizing oil and gas facilities present many different challenges. These challenges are not only technical, but also have an impact on the whole organization, including the workforce. Although robotics technology has already been proven in other industries, it must be applied and adapted to the specific applications of the oil and gas industry. These applications are typically carried out in extreme environments and are often located far away requiring remote operation ⁴. There are also system integration

issues with a prerequisite for full data access and availability.

The roles of the robot will, therefore, change from the more conventional single repetitive, yet continuous task, often encountered on a production line, to the execution of a number of different tasks, each requiring flawless performance on demand. The robot will have to operate at various levels of automation, from fully automatic, requiring no human intervention at one extreme, to completely manual operation at the other extreme. In between there will be various tasks with semi-automatic features, which will require varying degrees of human interaction. This represents a departure from the more traditional industrial robotics applications, in that human decision makers must be integrated within the control loop to collaborate with the robots and the control system. The successful automation of the oil and gas industry will, like all human-machine systems (HMS), rely on the seamless integration of man, technology and organization (MTO).

Oil and gas installations impose different demands on the design and requirements of the robot. The robot will have to be explosion-proof approved, in addition to being resistant to harsh weather conditions. Offshore robots will have to tolerate extreme temperatures, extreme winds, exposure to salt water and even exposure to snow and ice. Onshore robots will have to tolerate sand storms, direct sunlight, rain and humidity, extreme temperatures and exposure to different poisonous gases such as H₂S. Such specifications are not usually required for reliable robot operations in conventional manufacturing process plants.

To a large extent, the success of an automation project is influenced by the design of the facility in which the task is to be carried out. It is much more difficult to automate tasks in an existing facility than it is in new purpose-built facilities. The layout of existing facilities is not designed for standard industrial robots, particularly offshore topside installations, which

⁴ The offshore StatoilHydro Troll A gas platform located in the North Sea



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²⁾ Topside means offshore oil and gas installation (or the body of a boat or ship) above the water level.

Productivity solutions

are generally compact, presenting difficulties even to human workers when executing tasks. Modifying existing installations is rather limited and represents major costs. It is generally more effective to design new facilities, or to perform a major redesign of existing facilities, with the automated process in mind, so that many tasks can be carried out in a single facility and design features can be made to accommodate further additions should the process require scaling up. Such flexible facility design will allow greater process flexibility, increased productivity and reduced cost.

Telepresence keeps the human operators in the control loop, allowing them to use their high levels of skill to control the robot's operations.

While a robotized task, application or facility provides many safety and productivity advantages, it also presents additional challenges with regard to their maintenance and operation. Industrial robots are designed in general to replace human operators in the field; however, these robots are tools, which must be supervised and controlled. The robots themselves and how they perform a task should be of no concern to the human decision

makers. The human supervisor's role is to control the robot's operations through the automation system based on the need to monitor, inspect and maintain the oil and gas process equipment. Data concerning the state of the process equipment must be collected either automatically or on demand. Such data cannot replicate the human senses and hence, cannot provide a similar representation of the process as it is carried out today. However, the robots can use other sensors that human operators are unable to use, such as x-ray and computer chromatography. This so-called telepresence provides an advanced representation of the current process infrastructure so that human operators are kept in the control loop, allowing them to use their high levels of skill to complement the power of remote manipulators. Robots as extended operator tools make up a natural part of the IO concept. The robots represent assets that are fully integrated in the automation system. The various IO teams will base their understanding of the process and decisions on such representations.

The automation system receives and processes data collected by the robot before the system stores them for later use in other applications, or presents them directly to the operator, eg, in the form of a report. The operational team use this information to make decisions. Team members can also

actively search and ask for information. Their ultimate goal is to use all the information to monitor the current process and make decisions that will optimize the operation of the facility.

A major challenge for tele-operation within the oil and gas industry is, in particular, the remote nature of offshore installations. These can be located hundreds of miles away from land, conducting complex and dynamic operations in harsh environments. Operation failures in such installations may result in major consequences for the environment and process equipment. Safe and efficient tele-operation is critical for such unmanned facilities, securing added value and optimal productivity at remote locations.

The ultimate goal of the operational team is to use all the information to monitor the current process and make decisions that will optimize the operation of the facility.

There is a clear incentive for oil and gas companies to automate their oil and gas facilities, starting with isolated operations, such as pipe handling and assembly for drilling and tasks related to pig operations³⁾. These examples represent high-risk operations for humans and therefore provide opportunities to improve HSE. A major step in the future will be to fully automate larger parts of the facility or even the entire facility. Such an approach has the potential to make a large impact on the flexibility and productivity of a facility.

ABB oil and gas robot test facilities

Currently, three ABB robots communicate daily to perform inspection tasks on a "working" process module in an ABB facility in Oslo **5**. Either the control system or the operator initiates tasks for the robots. The (remotely-located) expert uses a 3-D process model to interface with the robots, defining and initiating tasks, and receiving feedback. The robots act as the operator's extended "eyes, ears and hands" in the process to maintain presence

5 The ABB robot test laboratory in Oslo, Norway



and awareness of the status of the process infrastructure. The focus has been to build and configure a highly advanced working facility for remote inspection. The robotics system is further configured to handle maintenance tasks, such as to open and close a valve, replace wireless sensors, or exchange components and handle material.

ABB, together with StatoilHydro, is addressing both the technical and personnel-related challenges in an ambitious cooperative research project to automate the oil and gas industry.

This lab provides a unique robot test facility to explore, demonstrate and test concepts for future robotized oil and gas applications. The lab is a part of a larger research project conducted

6 An ABB robot equipped for visual inspection mounted on flexible gantry crane



in collaboration with StatoilHydro to integrate remote automated operations. The main lab comprises three robots and a “working” process module. Typically, one robot is used for inspection and the other two for cooperative maintenance. The inspection robot is mounted on a flexible gantry crane, while the two maintenance robots are mounted on rails 6. In addition, a waterproof ABB robot is located outdoors at the StatoilHydro site in Kårstø (on the West coast of Norway). For a six-month test period the robot will be analyzed in severe weather conditions as a first step toward the creation of a robot able to withstand extremely harsh environments.

These two ABB robotics test labs provide excellent facilities in which to demonstrate and pilot a variety of automated tasks for the oil and gas business.

Robotized operators for the future

Oil and gas facilities have huge potential to increase productivity, a significant part of which will result from the use of robotics-based automation. In addition to productivity and efficiency gains, robots used for high-risk tasks will also lead to improvements in HSE. Such tasks are not necessarily always predictable and represent unusual robot activities. The robot will therefore require features that extend the “eyes, ears and hands” of the human decision makers as they carry out inspections and maintenance operations on the process infrastructure. The new role of the oil and gas facility operator will be to supervise and instruct the robots and to make operational decisions. The robotized facilities will allow marginal, remotely located fields to be cost effective for oil and gas production.

The greatest gains will come when the robotics systems are fully integrated with the automation system, providing a tool for the human decision makers that is aligned with the IO concept. The goal of IO is to make real-time data available to the decision makers in (virtual) teams so that they can make better and faster decisions. The robotized field operator is one of many means by which data can be

collected and tested to achieve a complete IO environment. A major advantage of robots is that such data collection tasks can be performed in environments impossible for human operators, such as those rich in H₂S, or can be collected using methods hazardous to human health, such as x-rays.

Two ABB robotics test labs provide excellent facilities in which to demonstrate and pilot a variety of automated tasks for the oil and gas business.

The degree to which the oil and gas industry benefits from robotics technology depends on how willing the industry is to change its organization and work processes in order to fully integrate the technology and overcome the technical challenges of IO.

ABB, together with StatoilHydro, is addressing both the technical and personnel-related challenges in an ambitious cooperative research project to automate the oil and gas industry. Access to operative sites, together with unique competence in robotics, oil and gas, and systems integration, means that ABB is well placed to develop integrated robots and automation systems specifically adapted for the harsh and demanding oil and gas industry applications.

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³⁾ These are operations that are performed within the pipeline, without stopping the flow, and include inspection and cleaning. Pigs get their name from the squealing sound they make while traveling through a pipeline.