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In Oil and Gas Refineries the Application of Robotics

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Abstract: **Oil and gas from conventional and non-conventional resources will become more and more challenging. The oil and gas industry will continue to boom in the coming future. Obtaining This intensifying need will impose very considerable demands on work force, financial and technology capabilities. Since the future supplies of oil and gas are to expand, advanced technology will become increasingly necessary to obtain access to more challenging conventional and non-conventional resources. Therefore oil and gas technologies will be very costly to operate in the coming future due to hostile, hard-to-reach environments. The offshore oil industry will become a complicated many of advanced equipment, structures, and work force. The present work identify potential applications and research directions of robotics in the oil & gas field and explore the obstacles and challenges of robotics applications to this area. This research performs the necessary survey and investigation about the work conditions of robotics and its equipment in the oil and gas industry, especially offshore oil rigs. The oil & gas industry processes are first investigated. The personals and tasks are then explored. Furthermore, this paper reviews the current robotics technology applied to various oil and gas industries. The challenges and requirements are identified for robotics in the oil and gas industry. The requirements of robotics and automation in the oil & gas industry are presented.**

I. INTRODUCTION

The oil and gas demand will grow rapidly in the next two decades. The oil and gas industry will continue to boom in the coming years. The intensifying need to obtain oil and gas from more hostile, hard-to-reach environments will increase the operation cost rapidly in the coming future. Hence, the oil and gas industry keeps looking for lower-cost solutions. To be competitive and to improve their profit margins, oil & gas companies are committed to cost reduction. They also look for ways to minimize employee costs and improve manufacturing efficiencies and quality besides seeking lower-cost suppliers and less-expensive raw materials. Because of the rising cost of employee salary and benefits like health care, the cost reduction effort in oil & gas companies is offset. Also high employee turnover adds the costs of retraining. Therefore, the oil and gas companies are looking for new technologies to reduce the labour cost. Also safety is a big concern in the oil and gas production. Using robotics in inspection, maintenance and repair could greatly improve the safety and efficiency. The oil & gas industry's presence is evident in its global networks of market supply and demand relationships. When there are fluctuations, regardless of their origins, consumers are affected in all over the world. Prices respond to changing markets with upward volatility because of an inelastic demand for oil and petroleum products. One solution to both the need for efficiency and maximum production and the capabilities required to further exploration is to implement robotics and automation in offshore oil & gas environments. Because the offshore oil & gas processes require advanced technologies, offshore environments will deploy the safest, most secure and consistent operations by utilizing industrial robotics and automation, and the latest software and mechanical devices. In order to investigate the challenges of robotics and automation in oil and gas industry, the necessary survey and investigation about the oil & gas industry processes, the personals and tasks should be explored first. The work conditions must be discussed to explore the requirements of robotics and automation equipment in the oil and gas industry, especially on offshore rigs. To meet the requirements and develop robotics and automation equipment in such work conditions, this paper reviews the current technology that has been developed and discusses the future research opportunities in the oil and gas industry.

II. INDUSTRIAL PROCESSES IN OIL AND GAS INDUSTRIES

Robot for painting is one of the earliest applications for industrial robot, however, the precision and finishing for the painting is an important issue for any painting job. Two software packages were used in this project. The Computer Aided Design (CAD) of the system work-objects and end effector was programmed based on Solid works software. Robot studio Software used to program the paths and target of the alphabets to be painted by the IRB1400 Robot which generate a RAPID GUI code used for robot interfacing. The final results demonstrate that implementation such system helps to boost the quality of painting, reduce paint consumption and improve safety. The result was able to boost the quality of painting, safety was improved with the usage of all the painting materials, and the cost of painting was reduced by using less paint. The integration of all the components of a typical robot was the driving factor in achieving the project objective. The offshore oil & gas industry is a complicated several of advanced equipment, structures, and work force. With a proper knowledge of offshore oil and gas rig environments, the applications of industrial robotics and automation are less abstract. Before any real vision of the potential roles robotics and automation in offshore oil processes can emerge, those processes must be enumerated appropriately. There are many products and services related to oil and gas with an equally substantial potential for markets within the industry. There are three stages through which petroleum products pass: upstream, downstream and midstream models. The upstream oil sector commonly refers to the searching for, recovery and production of crude oil and natural gas. It is also known as the exploration and production (E & P) sector, including searching for potential oil and gas fields, drilling of exploratory wells, and subsequently operating the wells to recover and bring the crude oil and/or natural gas to the surface.

The midstream oil and gas sector is the relay point for the upstream sector's products.

Midstream processes commonly refer to processing, transport, and storage of these products.

Because it is possible to produce pipeline quality gas for direct sale to an interstate or intrastate natural gas pipeline in the midstream sector, some treatment or processing of natural gas may occur in the midstream sector and bypass the downstream oil and gas sector completely. The midstream typically links the supply of the oil industry to the demand for energy commodities. The downstream oil sector refers to the refining of crude oil and the selling and distribution of natural gas, as well as other products derived from crude oil such as liquefied petroleum gas (LPG), gasoline or petrol, jet fuel, diesel oil, other fuel oils, asphalt and petroleum coke. The downstream industry touches consumers through thousands of products. These products include petrol, diesel, jet fuel, heating oil, natural gas and propane to asphalt, lubricants, synthetic rubber, plastics, fertilizers, antifreeze, pesticides, and pharmaceuticals. The oil and gas processes and the three sector model they fall into tend to parallel acrossthe onshore and offshore industries, however the processes will be distinguished when necessary if a distinct observation is being made.The major oil and gas extraction processes include the materials and equipment used and the processes employed.

There are four major processes in the oil and gas extraction industry:

(1) Exploration,

(2) Well development

(3) Production

(4) Site abandonment

After these processes are completed, the production process enters. It is likely the process in

which robotics and automation have the largest potential to increase efficiency and create a safer

environment for offshore oil and gas rigs, all while cutting construction costs for human necessitated rig designs. After the Deep Water Horizon oil spill in 2010, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) has implemented new mandatory regulations to replace old protocols for the offshore oil & gas industry. This is one area of operation that robotics and automation can dramatically improve efficiency, precision, safety, and decrease costs to companies. It is no stretch of imagination to suggest that robots and automation will soon be the primary means to effectively satisfy many of these new regulations.

Oil and Gas Refineries Challenges

The deep waters of the Gulf of Mexico, the frigid regions of Russia, and the hot, dusty, undeveloped deserts of the Middle East are merely the geographic challenges facing today's oil and gas exploration and production industry. The work conditions on offshore installations are the first thing to look at when analyzing the environments.

The most important ones are as follows:

• Atmosphere: The atmospheric conditions on offshore platforms are quite unfriendly. Due to the substances used and generated during the processing of hydro carbon resources, the following three types of gases can occur separately and combined: explosive, toxic and corrosive.

• Heavy weather: Wind with high speed and squalls, rain, hail and snow. All these weather conditions occur more often and more intense offshore than onshore.

• Extreme ambient temperature: Depending on the region the platform is located there can be extreme high and low temperatures. Humidity is also ranging from lower values up to condensing.

• Constraint space and/or walkways: The width of typical walkways is about 0.7 - 0.75 m.

Offshore rigs have further logistical issues: (a) it is highly expensive to have people working on the rig as they must be housed and protected; (b) in the case of emergency, it must be possible to evacuate personnel quickly.

As oil and gas exploration pushes into more hostile and remote regions, these difficulties become serious obstacles to the financial viability of an offshore installation. Reason for such hesitation derives from the logistical challenges that come with the implementation of a robot or an automated system in an offshore environment, as well as from a general lack of prototypes on the market. The oil and gas industry has grown accustomed to the use of systems controlled remotely by expert operators. But now projects that are underfoot could turn remotely operated vessels (ROVs) into highly specialized robotic systems. The industry is now to decide whether the use of robotics in subsea environments is inevitable and, if so, how much it will cost. Robots have clear advantages in some applications and safety is often a big factor in favouring their use in hazardous environments. There are so many tasks robots could do easily, far beyond inspection and maintenance. Now the challenge is to get oil and gas companies to use robots.

III. ROBOTICS USEFUL FOR OIL AND GAS INDUSTRIES

Robotics is a leading supplier of industrial robots - also providing robot software, peripheral equipment, modular manufacturing cells and service for tasks such as welding, handling, assembly, painting and finishing, picking, packing, palletizing and machine tending. Key markets include automotive, plastics, metal fabrication, foundry, electronics, machine tools, pharmaceutical and food and beverage industries. A strong solutions focus helps manufacturers improve productivity, product quality and worker safety. ABB has installed more than 200,000 robots worldwide. At the end of the 1980s, ABB and, later, Robot Norge invested in this wave and almost became the sole supplier to the Norwegian automotive parts manufacturing industry. Several hundred ABB robots were supplied to companies such as Farsund Automotive Casting, Hydro Structure Aluminium, Fundo Aluminium, Steertech, Raufoss Technology, Plastal, KA Automotive, Fibo and several others.

New Sources of Offshore Environmental Data

As oil and gas companies face increasing operational demands and technical complexities, access to new sources of offshore environmental data will be increasingly important. Traditional offshore environmental data acquisition methods (e.g. support ships, satellites and ROVs) for monitoring and surveying provide a valuable service. However, they are limited in range and mission duration and are expensive to use and maintain. Implementing innovative remote monitoring and survey technologies at lower acquisition costs and with greater operational efficiencies provides a significant business advantage. Liquid Robotics Oil & Gas brings this advantage through the delivery of continuous real time measurement solutions for applications including seep and containment loss detection, meteorology/oceanography (METOC), and subsea communications, in a highly cost effective manner. Delivered securely and on-demand, these services help customers meet the increasing demands that come from operating in ever more challenging environments.

IV. COMPONENTS OF A ROBOT

1 End Effector

End effector is the device at the end of a robot manipulator; it is designed to interact with the environment. This too l is used to perform the programmed application based on the required task.

For example a spray gun of a painting tool is used as the end effector for the painting robot.

Similarly, a design has to be developed for the robot end effector for the application of oil refineries according to their task. Every end effector has its specific design and dimensions. It requires the power input from external source that also has to be identified and make available for the operation.

2 Actuators

Actuators are like the muscle of the manipulator. They are controlled using the robot controller. They convert stored energy into movement [9]. The robot controller actuator uses air compressor when operational. A directional control valve was used in the direction of air fluid. The directional control valve have a fast response time of 12ms or less at a pressure of 0.5MPa without light/surge voltage suppressor and 15ms or less at a pressure of 0.5MPa with light/surge voltage suppressor. It has to response as fast as the movement of the robot set by the programming.

3 Sensor, Controller, Processor, Software and Object

Sensors are used to collect information about the internal state of the robot or to communicate with the outside environment. Sensors integrated into the robot send information about each joint or link to the controller, which determines the configuration of the robot. The integrated signal supply of the IRB1410 Robot is 12 single on upper arm with an integrated air supply of maximum 8bar on upper arm. For example of a robot painting, 24VDC relays is used as the sensor, to send signal to the directional control valve indicating when to activate the air compressor. This signal is usually sent to omron relay from the input/output signal controller of the robot. The controller of the robot controls the motion. It receives its data from the computer; control the motion of the actuators, and coordinates of the motion with the sensory feedback information. The IRC5 controller is used to control the IRB1410 ABB Robot and Virtual Flex Pendant is used to control the IRC5 controller. They are both connected by a cable. The processor is the brain of the robot. It calculates the motions of the robot joints, determines how much and how fast each joint must move to achieve the desired location and speeds, and oversees the coordinated actions of the controller and the sensors. The processor is a computer, which works like other computers, but is dedicated to a single process. It requires an operating system, programs, monitors, and have capability of a computer processor. The leFx Pendant is used as the controller for the IRB1410 ABB Robot. It works as the operating device for the robot. All application task and they program are being uploaded into the flex pendant. Base Ware Operating System is the processor operating system of IRC5 controller of the 1RB1410 ABB Robot. The Base Ware OS controls every aspect of the Robot, like motion control, development and execution of application programs communications [15]. There are three groups of software used in the robot. Base Ware OS is the operating system of the robot, Robot studio programming is used in programming the robot task and Solid work is used in Computer Aided Design (CAD) of the programming tools.

4 Software Developments

The most important aspect of any project is choosing the right end effector for the particular application. The manipulator is programmed based on the functionality of the end effector.

Depending on the end effector, the application process can be determined and therefore programmed. The end effector, and the work object (Board) is designed using the Solidwork software, and then imported to Robot studio as a CAD file for the programming of the paths and targets. Sometimes the program has to done using the backup system of the Robot. Afterwards, the digital output configuration of the air compressor was created using the Rapid Editor. This is to determine when the air compressor should be on/off. Finally, a backup system of the program is created and saved in a flash drive. The backup program is uploaded into the FlexPendant of the designed Robot connected to the specified controller. When the instruction is given to the Controller, it sends the information to the manipulation to perform the path and target being instructed. The air compressor comes on only when an ON signal is given by the Controller digital output signal to the directional control valve, which then controls the flow of air to actuate the end effector. The end effector goes off when OFF signal is given through the Controller digital output signal. When all the paths and targets of the program is completed, the robot goes back to its home position. The same procedure takes place when that designed Robot is taught using the FlexPendant on how to follow its paths and targets. In this case, no program needs to be uploaded into the system. The FlexPendant generate its program according to how the Robot is taught.

5 Hardware developments

The hardware design covers the Mechanical and Solid work design of the end effector and its attachment holder and the Work object to the Robot.

6 Robot Interfacing

Interfacing with the robot is the most important aspect of any project and as such is said to be most complicated aspect. Monitoring the movement and functionality of the robot and its joint, considering the entire safety factor and ensuring all procedure is met, understanding the use of the

Flex Pendant and how it works with the particular Controller. The end effector is mounted on the

Robot during interfacing process and the Tool Center Point (TCP) test was performed.

7 Manipulator

This is the main body of the robot; it consists of the links, the joints, and other structural elements. The weight of the robot is roughly 225kg. The robot is equipped with an operating system Base Ware OS. The Base Ware OS control every aspect of the robot, such as motion control, development and execution of application programs communications. The Robot can also be equipped with optional software for application support.

V. CONCLUSION

In this research, a brief introduction to the oil & gas industry processes is performed. The challenges and requirements for the robotics are explored. Future research opportunities including robot manipulator, mobile platform, tele-operation, and subsea robotics are discussed. Overall, one can assume that there are many opportunities in the oil and gas industry and some research is currently in progress to develop robotic and automation applications. Therefore, it is an optimal time to develop robotic and automation systems that can satisfy the oil & gas requirements. These examples represent high-risk operations for humans and therefore provide opportunities to improve health, safety and environmental performance. In addition to productivity and efficiency gains, robots used for high-risk tasks will also lead to improvements in health, safety and environmental performance. 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. Reduced commissioning and operation costs, together with improved Environmental, Health and Safety (EHS) are some of the potential benefits of having normally unmanned topside oil platforms. However, such oil & gas platforms require advanced methods and tools for remote control and monitoring of inspection and maintenance operations.

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