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Smart Field Technologies in Petroleum Engineering (Control and Monitoring)

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ABSTRACT

Aim of study is provide an introductory overview of "smart well" technologies in terms of control and monitoring, with the hope of contributing to the development of Libyan oil and gas fields and turning them into smart fields because the principle in petroleum engineering stipulates maximum profit, fastest time, least cost, maximum efficiency, minimum risk. Smart field technology can operate equipment automatically, improve oil field management, scientifically assist oil fields in decision making, monitor wells in real time, manage and monitor operations and control production, as well as predict potential risks and choose the best scenario for dealing with crises. This paper presents the definition and principle of smart wells and fields technology, a comparison between the types of smart technologies, their advantages and disadvantages, and how this technology contributes to the control and monitoring of oil and gas wells. Smart wells are technologies that use intelligent systems to improve the control and monitoring process in oil and gas wells. These technologies use the Skida system, wireless sensors, and data analytics, which use artificial intelligence to monitor and control operations within oil fields and facilities. Smart oil fields rely on wireless sensors and the Industrial Internet of Things. This technology makes it easier for oil companies to control performance, monitor in real time, and manage oil and gas fields, and makes it easier for management to make decisions. WSN is the most widespread technology used in oil and gas fields, as it provides sensors for remote control and monitoring and detecting faults if they occur. Internet of Things helps improve control and monitoring, as it is the operating system used by wireless sensors and connects them to the network so that we can control them.

INTRODUCTION

Smart Well Technology (SWT) is a technology that improves the performance of oil and gas wells and facilitates control and monitoring operations to achieve the highest performance in oil fields. Through it, we can achieve the highest levels of improving the performance of oil and gas wells and facilitate monitoring and control operations to achieve the highest performance in oil fields.

Smart Field Technology (SFT) develops oil and gas fields and transforms them from traditional fields to smart fields by introducing wireless sensors and the Internet of Things into well drilling, production, control and monitoring operations, thus increasing profitability and saving time and effort.

SCADA systems are an intelligent monitoring and control tool that stands for Supervisory Control and Data Acquisition. SCADA systems are used for monitoring and control, and these systems involve transferring data between a central SCADA host computer, a number of remote terminal units (RTUs) and/or programmable logic controllers (PLCs), and central host and operator stations. To develop traditional wells and fields and turn them into smart fields, wireless sensor networks (WSNs), a network of terminal nodes that transmit information collected from sensor sites via wireless links, have been linked.

They are then connected to an Ethernet backbone to transmit sensor information to the control system. WSN has proven its effectiveness in monitoring and control, and its presence has become essential in oil operations.

Recently, Internet of Things (IoT) technology has emerged in smart wells and fields, which is a group of networked devices that provide the ability to transfer data without the need for human interaction. It is easy to operate, control and monitor remotely, and handles a huge amount of data smoothly.

Objectives

The main objects of the study are the following:

1. Introducing Smart Well technology as an innovative approach to real-time monitoring and control of oil wells.

2. Comparison between traditional and smart wells and fields in terms of efficiency and quality of control and monitoring.

3. Presentation of Internet of Things technology and wireless sensors and knowledge of their applications and components.

4. Know the advantages and disadvantages of each of the advanced technologies in the field of oil industries

5. Providing recommendations regarding the development of control and monitoring systems in traditional oil and gas fields

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METHODOLOGY

In this study, I will review many of the smart technologies used in oil and gas fields, developed by leading companies in the field of information technology, and which are used in control and monitoring, these techniques are divided as follows

1) SCADA System
2) Wireless sensors networks System
3) Internet of Things System

SCADA System

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems, They are used to monitor and control plants or equipment in many fields such as oil and gas industry.

These systems encompass data transfer between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), the central host and the operator terminals.

SCADA uses a real-time database management system to increase the effectiveness of sending and receiving data and obtain optimal performance in the shortest time.

It runs on SQL and has technical features that improve performance efficiency, data accuracy, and seamless connection to external servers

Finally, the SCAD system is the most cost-efficient system on the market, featuring simple and low-cost maintenance.
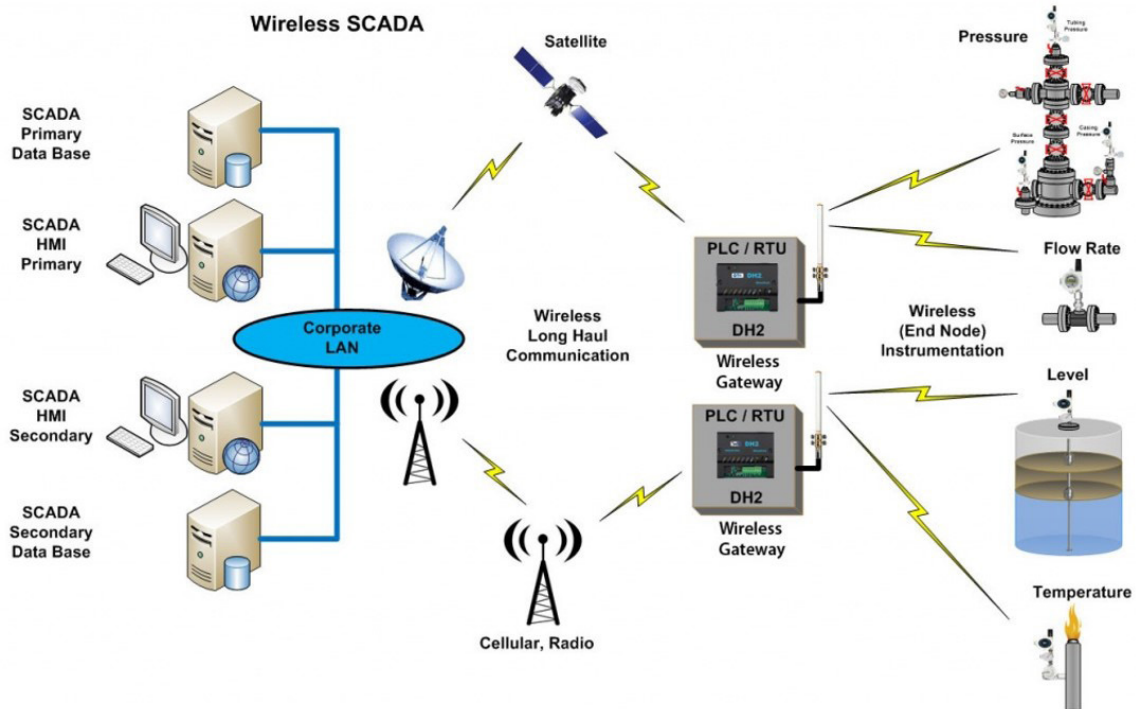

Figure 1: Typical SCADA System

Important of SCADA in Smart System
➢ Remote industrial control in oil and gas fields and Optimize performance
➢ Proactive maintenance and Downtime reduction.
➢ Interact directly with devices such as sensors, valves, motors, and HMI interface.
➢ Sequentially record events occurring in a process in a file or database.

Automated Well Test Application
Well testing is used to detrmine the performance of oil and gas wells, evaluate strata and extract parameters. By testing wells, we obtain formation permeability, skin factor, pressure, and other parameters

When testing wells collectively, these wells should be tested at intervals to determine the characteristics and performance of each well.

The Automated Well Testing feature, running in the logic controller, automates the well testing steps, the PLC allows a choice of three well test methods that differ according to level of automation:

The Automated well test application system allows the choice of three different automation methods
➢ Semi-automatic valve changes requiring manual intervention.
➢ Fully automatic valves test new wells using PLC.
➢ Well statistical testing controls valve changes based on testing time

Test data is stored in SCAD's production database and user can make appropriate geometric adjustments to the test time and units of measurement and divide the test into intervals
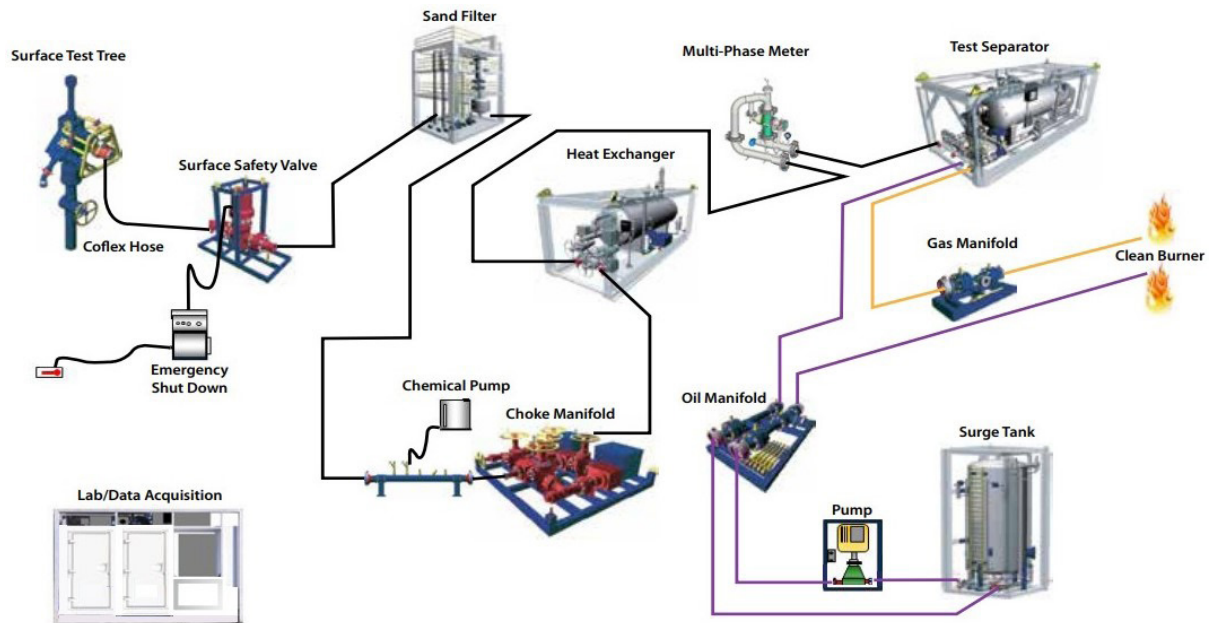
Figure 2: Typical well test equipment's

Rod Pump Optimization
The dynocard is one of the most important tools in the SCADA system to measure the efficiency of the downhole pump.
During the pump's operation, measurements of the well's pressure, temperature, and flow rate are recorded
SCADA application useful to:
➢ Monitoring remote wellsFocus on problem wells
➢ Knowing well faultsDetect abnormalities
➢ Predicting potential risks

Compressor Optimization
the greater the production and thus the profitability.
Compressors are the most important tools for increasing production in the fields.
The Skida system can display a graphical display of

compressor efficiency, as well as various compressor characteristics including flow rates and maximum capacity. Engineers use these charts to evaluate a compressor's production capacity and see which speed changes can improve production.

Phone Application
SCADA provides an application for mobile phones and smart devices to ensure ease of control, monitoring, and quick access to information anywhere and at any time.
Users receive audio or visual notification of playback problems from
1) Mobile phons
2) Email and SMS
3) Smart Tablets

Figure 3: Typical SCADA phone application

Table 1: SCADA Components & Functions

Serial	Tool	Function
1	SCADA Master	SCADA master is the most important part of the system. SCADA is considered the main program responsible for collecting data and sending control commands to devices connected to the oil fields..
2	Human	HMIs its computer master station systems within a SCADA system where human operators can track real-time data. HMI presents the data as an intuitive graphical image based on maps. People monitoring the HMI can then use the received data to make process or repair decisions.
3	Remote	RTUs are small computerized units installed in the field at certain sites. They are connected to sensors and actuators in the process and are also.
4	Programmable Logic	PLCs are intelligent devices (microcomputers) that communicate with HMIs, sensors, and RTUs. PLCs receive change requests from an RTU through a wired or wireless link and executes a change.

Wireless Sensor Networks (WSN)

A wireless sensor network can be defined as a network of end nodes communicating information gathered from sensor locations through wireless links.

Depending on the communications architecture, the data is either forwarded directly to a Gateway or perhaps through multiple end nodes back to a Gateway.

The Gateway is then connected to other devices or networks such as a wired or wireless Ethernet backbone to relay sensor information to a control system.

These networks are used to monitor a variety of conditions, covering all process control variables regardless of vertical market, including but not limited to Pressure, Flow, Temperature, and Level.

For the wireless communications piece, the sensor network end nodes are organized based on the topology implemented. By far, the two most common implementations
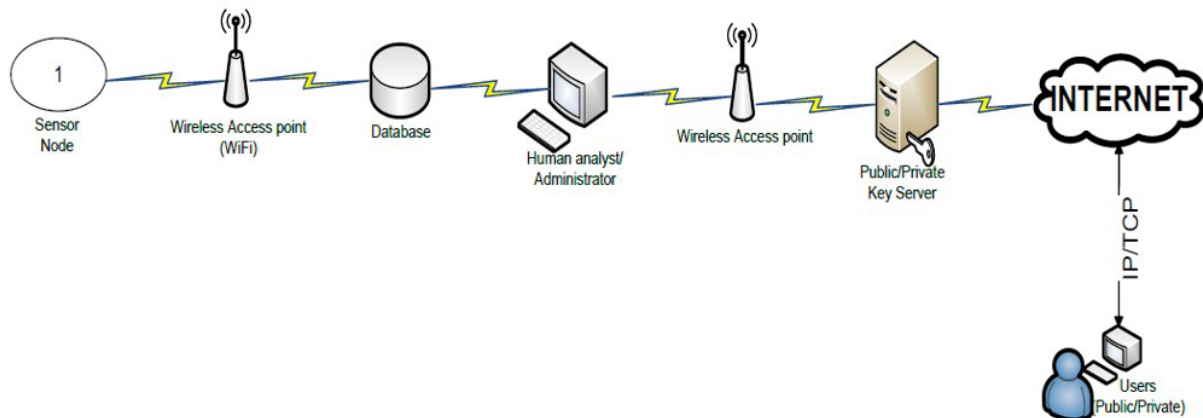
Figure 4: Typical Wireless Sensor Networks

Important of WSN in Smart System

➢ Condition monitoring and production optimization,
➢ Very important in remote and dangerous locations
➢ Provide real-time monitoring around the clock while minimizing the Risk to operators
➢ The difficulty and expense of introducing new wireline devices near pipelines
➢ Develops new control solutions that require more sensors

Application of WSN

Wireless technology has spread widely and has become the best alternative in terms of technical devices, and it continues to achieve great successes, thanks to its many applications. Its high efficiency compared to traditional

cable connections, and includes wireless sensors that measure pressure, temperature, volume, and flow rates.

Pressures

Well pressures in oil fields are monitored by introducing wireless sensors and monitoring pressure on a large scale. By monitoring pressure, we can predict potential risks and take countermeasures to prevent malfunctions and conserve resources.

Temperature

The temperature of wells in oil fields is monitored by inserting wireless sensors called resistance temperature detector (RTD). The device monitors the temperature of wells, compressors, pumps and motors in the facility

Flow Rate

The flow parameter is considered the most important parameter in oil and gas production, through which production efficiency, well injection rate, and other field applications can be known, wireless sensors, including differential flow and displacement devices, are used to monitor flow and know changes in real time.

Valve Actuation

Valves are the main production control tools, some operational and some for safety, emergency shut-off valves (ESD) can be automated wirelessly to shut down the well in emergency situations that prevent an explosion or catastrophic environmental accident.

Tank Levels

Measuring the level of parameters that change daily as a result of the daily production and conversion of oil and gas, Wireless sensors are inserted into the level measuring device for real-time monitoring. Its types are divided into resistive, magnetic, and hydrostatic pressure level.
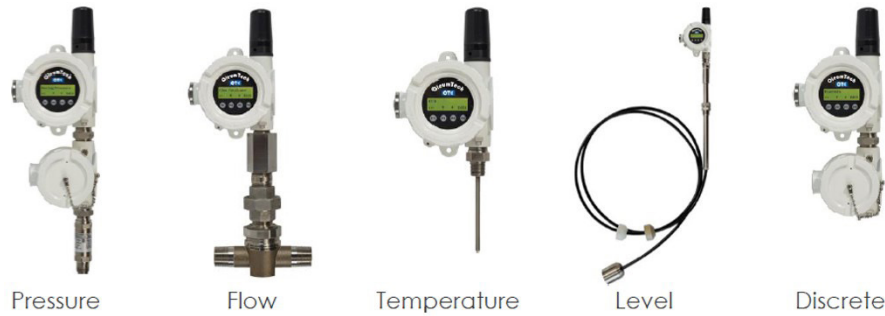

Pressure   Flow   Temperature   Level   Discrete

Figure 5: Wireless Sensor Networks Devices

Table 2: Types of Wireless Sensor Networks

Serial	Type	Description
1	Ground WSN	Ground sensor networks, consisting of multiple sensor nodes, whether random or pre-planned, that communicate with the control center
2	Underground WSN	To monitor underground wells, pumps and compressors This type is considered the most expensive, but it is very useful in oil and gas fields
3	Underwater WSN	In offshore oil and gas fields, autonomous underwater devices are used to collect data, including wireless sensors. This type is considered one of the biggest challenges of wireless sensors in terms of transmitting and receiving underwater.
4	Multimedia WSN	It is widely used in oil operations areas To monitor images, video, and audio transmissions
5	Mobile WSN	Provides better widespread coverage, better energy efficiency

The Internet of Things (IoT)

The Internet of Things (IoT) is a system that allows control of devices connected to it via a specific protocol and includes tools, sensors, sensors, and various artificial intelligence tools, and one of its most important features is remote monitoring and control
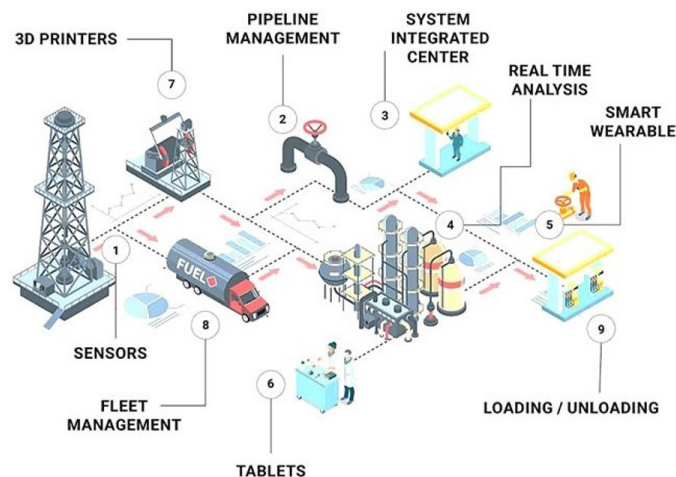

Figure 6: Internet of Things Applications

Through the Internet of Things, data is transferred without the need for human personnel, large amounts of data are collected and analyzed in the shortest time, and the best operating decisions are made based on this.

According to Internet of Things applications, oil and gas companies can automate operations, increase productivity, and reduce costs by predicting equipment and maintenance failures, reducing downtime, and increasing the safety rate.

Important of IOT in Smart System

➢ Real-time data collection, remote monitoring, and advanced analytics

➢ Anticipate when equipment is likely to fail so you can perform maintenance

➢ Improve efficiency, reduce downtime, save costs,

➢ Make better decisions leading to increased productivity and profitability

➢ Hazard management in oilfield and Reduced maintenance costs

Application of WSN
Process Monitoring
This feature is used by the Department of Oil Operations to monitor the performance of its equipment (pumps, compressors, heaters, separators).

Energy Management
Improves energy consumption by monitoring changes in the power source and electricity generation engines

Real-time Data
Collect massive information and analyze it smoothly in a short period of time compared to traditional methods

Predictive Analytics
Predicting faults before they occur, knowing maintenance times, and preventing losses in equipment and resources

Operational Optimization
By analyzing data, drilling and production operations can be improved, efficiency increased, and costs reduced
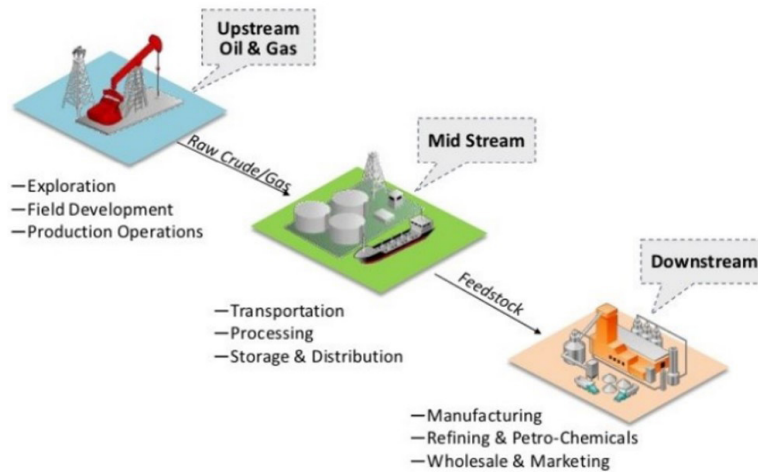

Figure 7: IOT fields in oil and gas industry

Table 3: IoT Components & Functions table

Serial	Tool	Function
1	Devices	Sensors or devices are mainly used to collect and transmit data and perform functions such as measuring temperature and pressure
2	Gateway	It is a link between sensors and the central cloud, providing communication, management, data processing, protocol translation, and reduced latency.
3	Cloud	Service that provides data management, storage and processing such as data preservation, data collection, security, connectivity, integration and efficiency
4	Analytics	This is the crucial component of IoT that basically harness the potential of IoT. In analytics, meaningful insights are analyzed that are generated by IoT devices and sensors. the applications of analytics in IoT: Anomaly Detection, smart Monitoring, Energy Management
5	User Interface	Provides an interface by which the users can interact with the applications and systems like Data Visualization, User-Friendly Design, Personalization, Remote Management, Integration, and Security.

RESULT AND DISCUSSION

Technology is important in the oil and gas industry because of the benefits that have been mentioned
In the results section, I will review the smart technologies and devices that transform fields from traditional fields to smart fields

Drilling Rig Monitoring System

The monitoring system is very important on drilling rigs Through an effective human-machine interface (HMI), operators can make the best decisions and reduce risks. Meanwhile, maintenance directly influences the performance of the whole rig team.
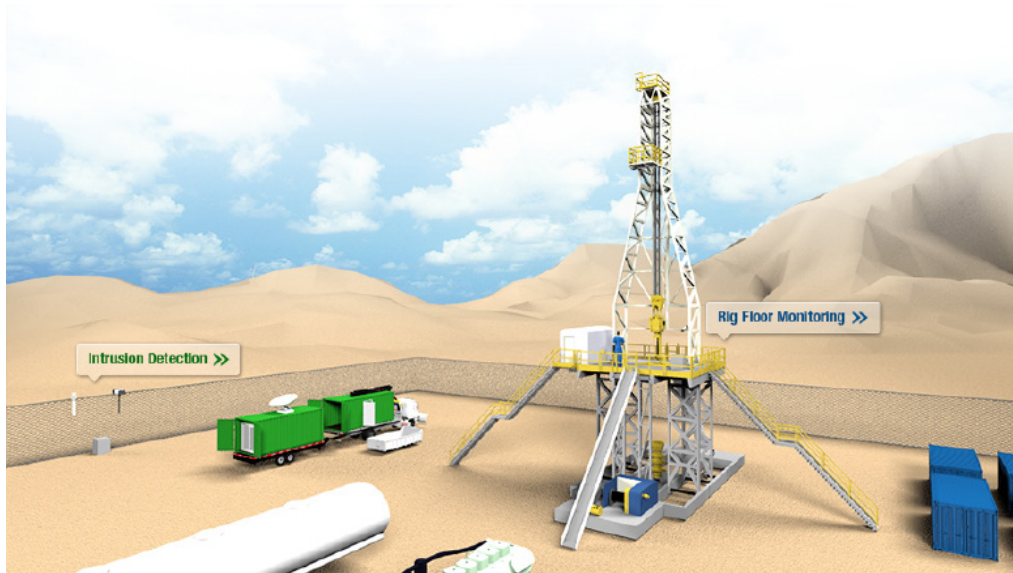

Figure 8: Drilling Rig Monitoring System

Keeping equipment working, and quickly replacing parts, ensures efficiency and reduces total cost of ownership.

Network Requirement

a) A rig floor HMI to act as an extension of the control center to reduce
   operational risks
b) Wireless communications for drilling sites to increase flexibility and cost effectiveness
c) Integrating complex oilfield equipment by WSN Devices

d) Product longevity and reliability for operating in harsh environments

Upstream Monitoring System

Intelligent process automation can be achieved with a reliable Ethernet control and monitoring system that supervises operations from the wellheads, or Gas Oil Separation
Plant (GOSP) in a SCADA-based control center.
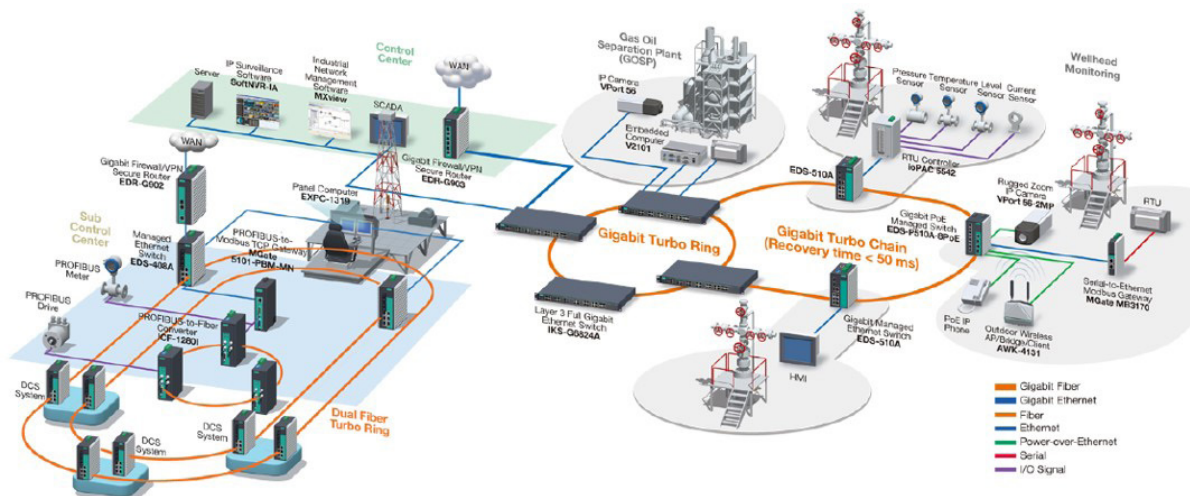This system combines field site production data transmission and acquisition and video monitoring

Figure 9: Upstream Monitoring System

Midstream Monitoring System

Typically, pipelines span several thousand miles over harsh terrain and require a central SCADA system based on Synchronous Digital Hierarchy (SDH) and microwave architecture to measure, monitor, and control the status of field instruments across the entire oil flow.

Multiple pumping stations, such as block valve stations and compressor stations, keep the pressure in the pipeline constant.

Operators can quickly detect, locate, and prevent or resolve leaks, damages, and breaks by deploying a rugged, extendable fiber-optic Ethernet network.
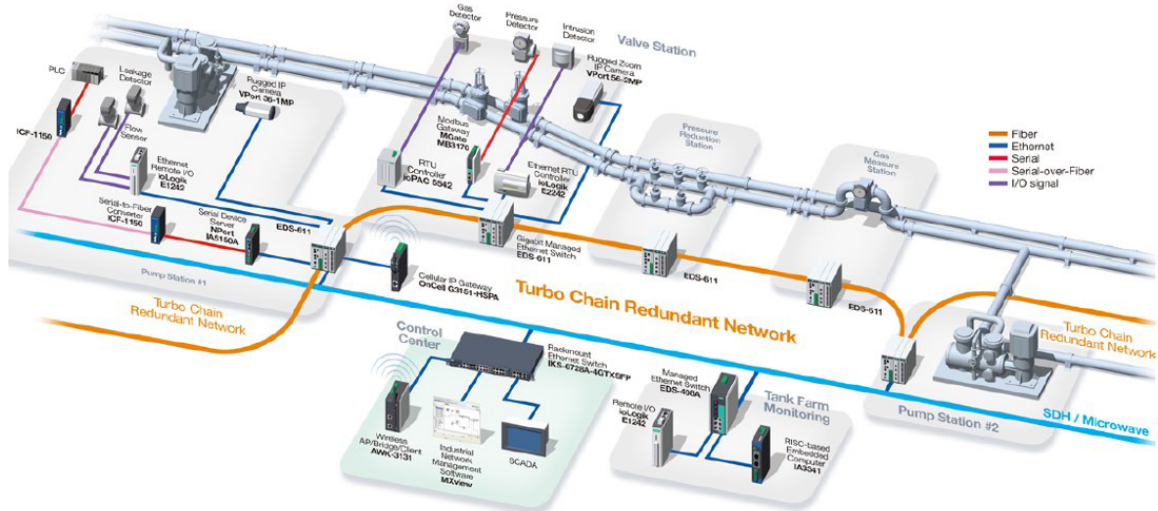

Figure 10: Midstream Monitoring System

Network Requirement

a) SCADA system and a reliable Internet network to monitor operations

b) Connecting the remote data monitoring system to the control center.

c) Fiber optic cable for long distance transmission.

d) High-bandwidth communication column for transferring image and video data.

Downstream Monitoring System

Oil refineries are facilities that refine crude oil and extract petroleum derivatives

Due to its multiple and complex operations, smart field technology provides monitoring and control devices that facilitate the work of refineries by linking wireless sensors to the facility's work system.
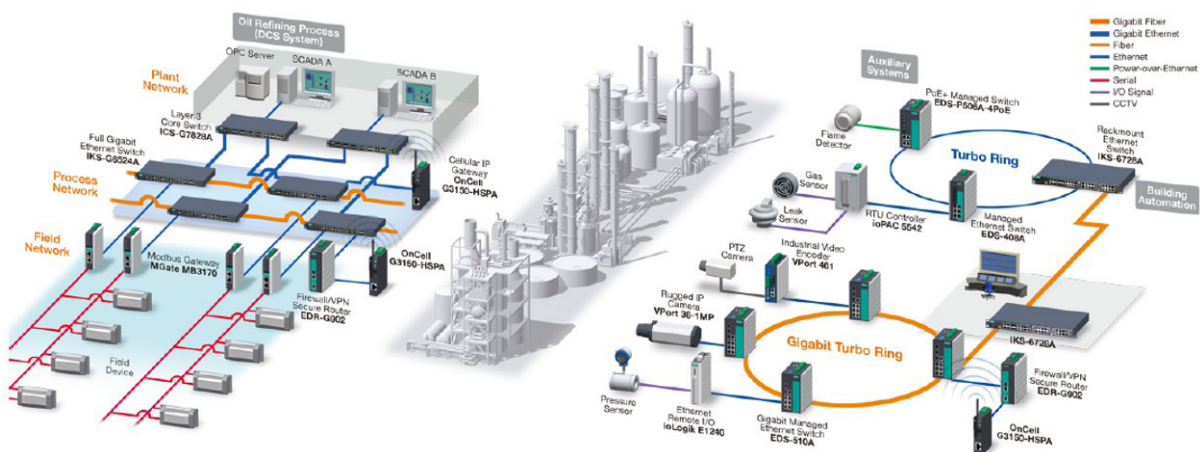

Figure 11: Downstream Monitoring System

Network Requirement

a) SCADA system and a reliable Internet network to monitor operations

b) Connecting the remote data monitoring system to the control center.

c) Fiber optic cable for long distance transmission.

d) High-bandwidth communication column for transferring image and video data.

Real-Time Oilfield Monitoring System

Real-time monitoring is Providing continuous updates about operations within oil and gas fields by sending direct, real-time information about the events. It enables quick detection of operational fauliers and performance.Exploiting oil and gas fields needs to use the wide-area remote monitoring system, to monitor the output efficiency of oil and gas and the operation condition of machines and tools.
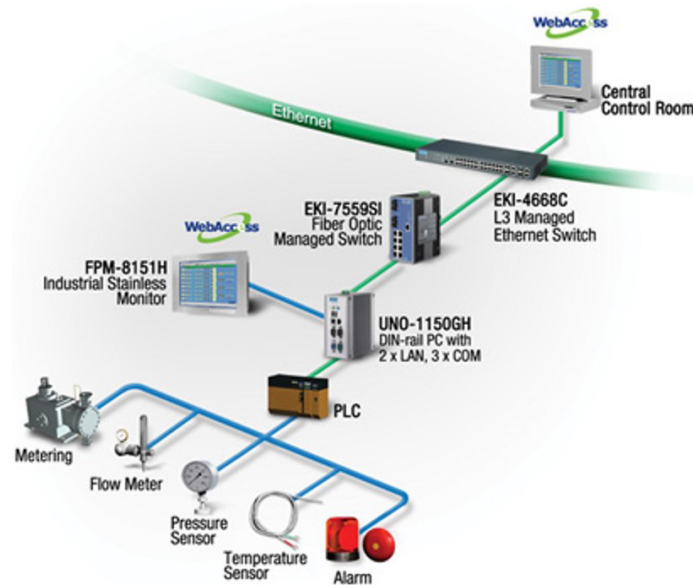
Figure 12: Real-Time Oilfield Monitoring System

Network Requirement

All what we need is Measure and record the oil temperature, temperature, pressure, flow velocity and other parameters of the pump unit, read and store the information of the indicator, and upload it to the center. In addition, Zigbee needs to be connected to the wireless temperature and pressure and other sensors in the field.

CONCLUSIONS

Based on the results of this study, the following conclusions are obtained: (SCADA) systems control, monitor, and analyze industrial devices and processes. (WSNs) are used to monitor and collect information about the physical conditions of oil fields. (Internet of Things) is a technology that connects devices to the Internet to communicate with other devices and share data. (SCADA) system includes data collection devices such as sensors and relays, data processing devices such as a PLC or RTU, and data display devices such as an HMI or monitor. (WSNs) is typically made up of a large number of small, low-power sensors that transmit data wirelessly to a central base station. (Internet of Things) typically consists of a smaller number of devices connected to the Internet via wired or wireless connections. (SCADA) systems is fixed collection of software, computer hardware, network data connections, and user interfaces. (WSNs) are static, where sensors are placed in a specific location and remain in that location. Internet of Things) is more dynamic, as devices and objects are moved and connected to multiple networks.

RECOMMENDATIONS

The main recommendations we can get from this study are:

Drilling Engineering Department

Providing wireless sensors to monitor drilling parameters (WOB-RPM-SPM-ROP) to serve as an extension of the control center, which helps reduce operational risks, obtain real-time information and save drilling downtime costs.

Production Engineering Department

provide Smart gas-lift control to optimal amount of injection gas to every well and get the most out of each and every gaslifted well.

Provide Smart ESP pump system to remote monitoring and control of and estimation of parameters such as production, energy consumption and dynamic fluid level.

Reservoir Engineering Department

smart well technology allows reservoir engineers to adjust the flow of fluids in real time, based on the data collected by the sensors, Also allow reservoir engineers to perform zonal isolation, selective stimulation, temperature measurement, and pressure testing, which can improve the reservoir performance and extend the well life.

Operation Management Department

SCADA must be developed from the first generation (monolithic), which relies on mainframe systems, to the third generation (networked), which communicates via networks, allowing control and monitoring on a large scale, and using wireless sensors to collect production parameters (pressure - temperature - flow rate)

Nomenclature

SWT = Smart Well Technology
SFT = Smart Field technology
WSN = Wireless sensor network
SCADA = Supervisory control and data acquisition
IOT = Internet of Things
CW = Conventional Well
SW = Smart Well
HMIs = Human-machine interfaces
RTUs = Remote Terminal Units

PLCs = Programmable Logic Controllers
RTD = Resistance Temperature Detector
ESD = Emergency Shutdown
DCS = distributed control system
SDH = Synchronous Digital Hierarchy
ROP = Rate of Penetration
WOB = Wight on bit
RPM = Rotation per Minot
SPM = Strokes per Minot

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