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Growing Role of Artificial Intelligence (AI)

In

Oil and Gas Industry

By

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Declaration by the Guide

This is to certify that the Mr /Ms Surabhi Patni, a student of MBA in Oil and Gas, SAP ID 500057225 of UPES has successfully completed this dissertation report on "Growing Role of AI in Oil and Gas Industry" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by her in particular oil and gas company and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA/BBA/B.Sc.

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Executive Summary

This thesis aims to study the growing role of Artificial intelligence (AI) and associated technologies in oil and gas industry. The oil and gas industry is becoming more and more data-driven to enable it to be more resilient to multiple variables that can affect its performance in face of globalisation. There is an increased focus on improving efficiency, reducing downtime, reservoir management, better customer experience and companies looking at innovative ways to improve the same.

The chapter 1 of the thesis gives a brief introduction of the objectives of the thesis. Chapter two is a detailed literature review from published sources. Chapter 3 summarizes the research methods. Two publicly available case studies and one case study highlighting work done bu author and team using simple AI algorithm for predictive analysis in company X along with benefits obtained are detailed in Chapter 4. Chapter 5 is on discussion of results and chapter 6 gives conclusions , limitations and recommendations for further work.

The author demonstrates using the case study for company X how even inhouse simple AI algorithms can help create value in millions of dollars for the assets. It is evident from research done that AI applied across statistical and empirical models is already being used to help take asset management decisions leading to a dramatic improvement in equipment reliability and reduction of down time. There are certain limitation like high initial costs, lack of trained manpower and sparse work on socio economic impact of increased AI integration in the industry.

In general though AI and associated technologies are and will enable people to make better informed, data-driven decisions resulting in lower cost, more safe and reliable assets and significantly better environmental performance. These technologies will help process data and create algorithms to solve multivariable problems much beyond the capability of the normal human mind. The author can confidently say that integration of these technologies is already in process of dramatically improving the oil and gas industry and hence making the world a better place.

CHAPTER 1: INTRODUCTION

1.1 RESEARCH BACKGROUND

Oil is considered as a most valued commodity in the sector of energy which estimate the total energy investment in 2016 was 1.7 trillion dollar that represent 2.2 % of the Global Gross Domestic Product[1] as a result it is considered as the main concern over the environmental impact of energy production and consumption especially in the field of Oil and Gas companies which are actively speaking innovative approaches to achieve their goals by reducing the impact and mentally in the present time artificial intelligence helping the oil and gas industry to examine and forecasting future force although there is no previous sources that have provided in depth information about the impact of artificial intelligence among the oil and gas companies but it indicate the type of artificial intelligence applications that are currently used especially in oil and gas companies such as Access on mobile and shell apart from this it has been reported that artificial intelligence application implemented in oil and gas companies and also focus on the common trends among their innovation efforts that Highly Effective future of the oil and gas industry respectively.

In order to examine the artificial intelligence in oil and gas it mainly focus on the most popular application of artificial intelligence from the top five industry it may be in the form of intelligent robots that are designed with artificial intelligence capability for hydrocarbon exploration and production so that it can improve the productivity and also consider as a cost-effective by reducing worker risk apart from this virtual assistant is also considered as the online check platform that help the customer to navigate their product database and processes[2] that are general enquiries by using natural language for example Royal Dutch Shell also recorded in August 2015 and consider the force company in the lubricant factor that launch artificial intelligence assistant for the customer with the help of these application customer can search for the lubricant and related products and navigate a large data space in order to find idle product apart from this the company also focus to use its a pad and Ethane to help the customer to find out different type of product by using natural language with the help of virtual assistant function shell also at the online check

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[1] Dai, Hancheng, Xuxuan Xie, Yang Xie, Jian Liu, and Toshihiko Masui. "Green growth: The economic impacts of large-scale renewable energy development in China." *Applied energy* 162 (2016): 435-449.

[2] Chaffey, Dave, Paul Russell Smith, and Paul Russell Smith. *eMarketing eXcellence: Planning and optimizing your digital marketing*. Routledge, 2013.

platform through the company's website as a result the company e handle over 1 lakh data sheet for 3000 product and provide information on 18000 different pack sizes by understanding 16500 physical characteristics of lubricants.

Artificial intelligence also considered as a diverse scientific field but within the oil and gas industry there are two primary application of Technology such as machine learning and data science machine learning help the computer system to learn and interpret data without the without making human I'm put it on the refining the process with the help of attraction to produce program for a specific purpose in the field of Oil and Gas industry machine learning help the companies to monitor their Complex and dynamic internal operation and respond quickly by concerning that human operator may not have been able to detect it also used to run simulation by using predictive data models to discover pattern that are totally based on the variety of inputs in the field of oil and gas in the Industry kit can be used as a artificial Intelligence and wait to take the potential impact of the new development and identify the environmental risk by operating a new project before any plan are made additionally with the help of data science it uses as a artificial intelligence to extract information and help from the data by using neural network that are related with the pieces of data together and develop more comprehensive picture for the existing information in the field of Oil and Gas industry it can use as a artificial intelligence in a data size to make Complex data and used for the oil and gas production which are considered as a more accessible and has the country to find out new exploration opportunities.

In the field of smart production system it is essential to adapt innovative solution that automatically increase the quality and sustainability of the manufacturing activities by reducing the cost in the field of artificial intelligence driving Technology it leveraged buyout 14.0 key enabling Technologies for example internet of think Cloud Computing big data cognitive system virtual and Augmented reality[3] That generate new industrial faradism the availability of such kind of application provide potential to improve the process and quality of product in a sustainable manner apart from this it has been recognised that there are so many information that can also propose the challenge and make a negative impact for example distract from the main issues and create delayed or wrong conclusion about the appropriate action as a result it can be said that it can be safely

[3] De Kare-Silver, Michael. *e-shock 2020: how the digital technology revolution is changing business and all our lives*. Palgrave Macmillan, 2011.

concluded and manufacturing industry has to be except that in order to benefit from the increase data availability for example for quality improvement initiatives manufacturing cost estimation process Optimisation better understanding of the requirement of the customer that help and needed to handle the Harry dimensions complexity and dynamic which are involved in the process it also identify the product and process driver in manufacturing system by using supervised machine learning.

The use of advanced software to analyze data and provide recommendations for improving operational performance is not new to the oil and gas industry. Since the early 1990's, operators in the upstream segment have been using a wide range of technologies designed to ingest and analyze information pertaining to downhole conditions (for example temperature, pressure and geophysical makeup), drill bit performance and reservoir dynamics. For many years, however, the implementation of these tools required a significant up-front investment, which meant that they could only be financially justified on wells with high production levels.

Wireless networks and remote sensors that can collect and transmit data from a variety of measuring points are becoming increasingly common in the oilfield.[4] So is the use of advanced software solutions featuring complex machine learning algorithms, which have the capability to sift through terabytes of data to identify patterns, make predictions and provide recommendations to operating personnel regarding how to optimally control and manage their assets. In operations featuring a high level of automation, software bypasses humans entirely and makes micro-adjustments to parameters such as individual pump strokes, rate of penetration and chemical injection rates to maintain optimal production and efficiency. CBR systems can be used by themselves or in conjunction with other analytic solutions. They have become more prevalent throughout the drilling sector and provide operators with recommendations on how to deal with a variety of downhole-related issues. The technology itself can be an effective tool for developing best practice guidelines, and has become a useful aid for personnel tasked with making difficult decisions. CBR-based systems are limited, however, in that they require a large searchable case library/database and a succinct description of current problem situations in order to be effective. Collected data can also be used to track equipment performance, helping to predict mechanical

[4] Heidemann, John, Wei Ye, Jack Wills, Affan Syed, and Yuan Li. "Research challenges and applications for underwater sensor networking." In *IEEE Wireless Communications and Networking Conference, 2006. WCNC 2006.*, vol. 1, pp. 228-235. IEEE, 2006.

failure and alert operators of potential disruptions so unplanned equipment downtime can be minimized. As the software ingests more data, its ability to make predictions improves, adapting and becoming more intelligent over time via a learning method similar to human intellect. Another technology that exploration and production companies are leveraging alongside machine learning algorithms is case-based reasoning (CBR). CBR is a subset of AI that works by scouring databases of documented problem cases in real-time to attempt to identify cases similar to the issue being encountered. Once a case that has a matching description is retrieved, the system digs deeper to see what actions were taken to address the issue.

1.2 RESEARCH PROBLEM

Oil is one of the most precious commodities in the energy sector. With the volatility in the oil prices , depleting crude oil levels globally and challenge from renewable sources of energy, organizations involved in the oil and gas industry are now turning towards modern technologies, specifically Artificial Intelligence, to maximize and optimize their efficiency, reduce environmental impact and revenues.

1.3 AIMS AND OBJECTIVES

The oil and gas industry is usually divided into three major operational sectors: upstream, midstream, and downstream. Upstream involves the exploration and production of oil and natural gas. Midstream usually refers to transportation and storage stages. Downstream encompasses the various processes involved in refining and selling oil. Artificial intelligence (AI) is proving to be a cost-saving investment for the oil and gas industry. It is increasingly being used to improve various upstream, midstream, and downstream processes in the industry, from boiler diagnostics to actual drilling. Applications such as quality control, prediction planning, and predictive maintenance for upstream, midstream, and downstream are majorly using AI.

- Enhancing the operational efficiency
- Reduced costs
- • Better safety measures
- Finding new resources

The research aims to study exiting applications of AI in Oil and gas, demonstrate via case study analysis how value can be created by integrating AI in processes within Oil and gas industry and briefly summarize scope for further research in the field based on research during the thesis.

1.4 CONTRIBUTION OF THE STUDY

Since time unknown the humans have been intrigued by the possibility of creating machines that mimic the human brain. In modern times, the term artificial intelligence was coined in 1955 by John McCarthy. In 1956, McCarthy and others organized a conference titled the "Dartmouth Summer Research Project on Artificial Intelligence." This beginning led to the creation of machine learning, deep learning, predictive analytics, and now to prescriptive analytics. It also gave rise to a whole new field of study, data science. Today, the amount of data that is generated, by both humans and machines, far outpaces humans' ability to absorb, interpret, and make complex decisions based on that data. Artificial intelligence forms the basis for all computer learning and is the future of all complex decision making. AI works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing the software to learn automatically by recognizing patterns in the data. Forms of AI in use today include, among others, digital assistants, chatbots and robots. Computers are extremely efficient at calculating these combinations and permutations to arrive at the best decision. AI (and its logical evolution of machine learning) and deep learning are the foundational future of business decision making. AI includes many methods and continuously evolving range of technologies, as well as the following major subfields like Machine learning (ML) , Natural Language Processing (NLP) and Deep Learning (DL). The potential of Artificial Intelligence is already being discovered by many industries, including the Oil and Gas, which is investing majorly in Artificial Intelligence and other data technologies with a goal to secure their future competitiveness in a fast-changing environment

1.5 THESIS STRUCTURE

- Chapter 1: Introduction

This section of the chapter will include a brief description of the topic that the researcher is going to conduct the study about. This will also discuss the different parameter that is included in the research study like problems and significance of the study.

- Chapter 2: Literature Review

This section will include all the information which are collected by the researcher related to the various past study research studies. It will help to provide a general understanding of the research study topic.

- Chapter 3: Research Methodology

This section will include all the process and approaches that will be used by the researcher to collect and analyze the facts and figures in a proper manner.

- Chapter 4: Data Analysis

This section will present all analysis of case studies and experimental work conducted.

- Chapter 5: Discussion and Interpretation of Results

This section will effectively analyze the different facts and figures that have been collected by the researcher.

- Chapter 6: Conclusion and Scope for Future Work

This section will include all the results and outcomes that have been acquired after conducting the effective examination of the data collected by the researcher.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The use of advanced technologies such as Artificial Intelligence (AI), machine learning, and predictive analysis have increased in the oil and gas industry. The technologies help the oil and gas company to increase efficiency, overcome unexpected downtime, lessen costs, and face a drop in oil price challenges effectively.[5] The oil and gas industry forms an integral part of the energy sector and represent 2.2% of the global Gross Domestic Product. The use of AI in applications in the form of intelligent robots and virtual assistants helps in reducing worker risks, augmenting productivity, and navigating product databases for consumers. The current study provides relevant information about AI, the need for AI, and the application of AI in different sectors. The study also provides valuable facts about the application of a range of technologies in the oil and gas industry and identifies the Application of a range of technologies in the oil and gas industry. The study also discusses how AI can transform oil and gas industry operations.[6]

2.2. Background and evolution of AI

Artificial Intelligence (AI) is a scientific process that increases the capabilities of machines. In AI applications, the machines are programmed to think like humans and conduct activities based on learning, reasoning, and self-correction.[7] The evolution of AI took place in the year 2007 with the launch of CUDA by NVidia. Later on, discoveries were brought in AI application with the help of deep learning in the year 2009. Likewise, more innovations in AI led to the inclusion of Machine Learning in the year 2011 which increased the use of AI applications in different sectors such as healthcare, oil and gas industry, automobile industry, and construction industry. Artificial Neural Network (ANN) is also included in the AI applications which helps in optimizing organization

[5] Bravo, César E., Luigi Saputelli, Francklin Rivas, Anna G. Pérez, Michael Nickolaou, Georg Zangl, Neil De Guzmán, Shahab Dean Mohaghegh, and Gustavo Nunez. "State of the art of artificial intelligence and predictive analytics in the E&P industry: a technology survey." *Spe Journal* 19, no. 04 (2014): 547-563.
[6] Timilsina, Govinda R., John C. Beghin, Dominique Van der Mensbrugghe, and Simon Mevel. *The impacts of biofuel targets on land-use change and food supply: A global CGE assessment.* The World Bank, 2010.
[7] **Wang, P. Three fundamental misconceptions of Artificial Intelligence. J. Exp. Theor. Artif. Intell. 2007, 19, 249–268.**

workings, forecasting demand and supply, and helping managers to make rightful business decisions.[8]

AI applications create technologies that allow computers and other equipment to function effectively. It helps in problem solving, knowledge representation, planning, learning, and natural language processing. It is effectively used in the quality control process to recognize the early signs of production failures and improve the response time. It is also included in the predictive maintenance process to identify the possible manufacturing malfunctioning and provides relevant information regarding the repairing of machinery. The AI applications are also used in the energy consumption segment so that there is efficient utilization of resources and synchronization of logistics and supply chain management.[9]

2.3. Need for AI

The market has a flourishing plethora of other technological innovations such as Blockchain which is used for asset management, record keeping, and claim processing purposes. However, due to cybersecurity problems, scalability issues, immutable data concerns, and high cost make it difficult for the firms to install and operate in blockchain networks cloud computing is used in different sectors such as education, healthcare, and businesses to manage data and enhance the consumer experience. However, due to increased downtime, security concerns, privacy risks, and limited flexibility the use of cloud computing get restricted. It creates vendor lock-in situations and increases the cost of the company for the installing and upgrading of the operating system that discourages the firm from implementing blockchain technology. AI is highly useful as it helps in improving workplace communication, streamlining manufacturing, and standardizing supply chain process operations. It also helps in automating learning, organizing social media feeds, optimizing travel, and navigation. Additionally, AI technology uses different approaches like cybernetics, brain simulation, symbolic, statistical learning, and integrated approaches to provide motion, manipulation, and other services to the firm.

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[8] Autry, Chad W., Thomas J. Goldsby, John Bell, Mark A. Moon, Chuck Munson, Michael Watson, Sara Lewis, Peter Cacioppi, and Jay Jayaraman. *The definitive guide to modern supply chain management (collection)*. FT Press, 2013.

[9] **Dyckhoff, H.; Lackes, R.; Reese, J. Supply Chain Management and Reverse Logistics; Springer: Berlin/Heidelberg, Germany, 2004**

2.4. Application of AI in a different sector

AI is used in different sectors such as the healthcare industry as it helps in enhancing healthcare accessibility. It also helps in the early detection of diseases, assists in surgery through Antibacterial Nanorobots, and supports patients with the help of an exoskeleton. However, the use of AI in the healthcare sector gets restricted because of the lack of personal involvement of healthcare professionals. AI may also present an incorrect analysis and impact employment status in the healthcare sector. AI is also used in the construction industry as it helps in risk mitigation by using Construction Language Analytics. By using tools such as Autodesk BIM 360, AI provides rightful information such as weather forecasts which helps the contractors to make rightful construction decisions. AI also increases safety at the workplace and helps in reducing injury or fatality rates at the site. AI-based tool such as SMARTVID.10 identifies labor and equipment by him/her to perform the task. It helps in recognizing the capabilities of the individual to use the equipment and ensures that high risks tasks are performed by the skilled laborers. However, the increased use of AI applications in the construction industry negatively impacts the economic growth process by increasing high unemployment levels. As per the research conducted by Mace, it was found that due to the increasing use of AI-based software, applications, and tools, about 600,000 individuals will be losing their jobs by 2040. Thus, it can be said that AI application negatively impacts the long-term growth propositions of the economy.

2.5. Application of a range of technologies in the oil and gas industry

The oil and gas industry has been classified into three major operational sectors such as upstream, midstream, and downstream. Upstream includes the exploration and production of oil and natural gas while midstream refers to transportation and storage stages. Downstream encompasses the various processes involved in refining and selling oil.[10] AI is extensively used in the upstream, midstream, and downstream processes of the oil and gas industry to automate tasks, enhance drilling, and perform ESP monitoring activities. For example, Hindustan Petroleum Corporation Limited's (HPCL) has implemented AI applications to manage data, include geo map features, and enhance sales analytics procedures. As per the survey conducted by McKinsey, it

[10] **Al-Janabi, Y. T. (2020). An Overview of Corrosion in Oil and Gas Industry: Upstream, Midstream, and Downstream Sectors.** ***Corrosion Inhibitors in the Oil and Gas Industry*****, 1-39**

was found that the oil and gas industry mainly implement AI technology to automate 60% to 90% of its routine task procedures. It helps in increasing workplace efficacy, reducing human errors, and accomplishing tasks in real-time. AI is also used for the oil drilling process in the gas and oil industry which is associated with hydrocarbon exploration beneath the earth. It includes using AI-based drones and bots for critical activities by replacing humans so that there is a reduction in injuries in high-risk regions.

AI helps in finding new resources, enhancing operational efficiency, predicting data intelligence, and providing better safety measures. It includes Big Data Analytics which helps to analyze, capturing, and optimizing the midstream, upstream and downstream operations. Big data analytics also helps in reducing drilling time, improving petrochemical asset management, evaluating seismic data, and ensuring occupational safety. AI-based machine learning is also used in the oil and gas industry to optimize drilling operations, enhance reservoir modeling, and troubleshoot the underperforming wells. It also helps in process optimization and improving subsurface characterization. For example, AI-based Machine Learning is used by Shell to create end-to-end coupled drilling operations by establishing connectivity with other equipment such as drilling metric, vibrators, and mechanical specific energy (MSR) operators. Thus, it can be said that AI is used in the oil and gas industry to enhance production performance, augment operational efficiency, and ensure better safety measures cost-effectively.

2.6. Internal and external issues in the oil and gas industry

The implementation of AI in the oil and gas industry is not easy as it includes highly skilled laborers and working staff. AI is a scientific method of enhancing the capabilities of machines to think and work such as humans. To introduce specific algorithms related to predictive and preventive maintenance or finding shale resources require skilled personnel and technical abilities. It includes the active involvement of experts so that the oil recovery rate for drilling and exploration data is received and assessed. However, the oil and gas industry lack efficient skilled personnel which creates issues in the adoption of AI in the oil and gas industry. Global political issues also impact the application of new technologies in the oil and gas industry. There is a cut-throat competition between the oil and gas companies at global levels in which the geopolitical battle plays an important role in determining the global market share of the firms. Under such

conditions, the governing bodies adopt different policies to exercise control over the workings of oil and gas firms and provide them directives international dealings. The oil and gas industry is laggard in implementing digital transformation. There is a lack of internet interface in the oil and gas industry which creates issues in the adoption of AI-based technologies. In case, even there is an adoption of internet interface, emerging issues such as safety and cybercrime impact the oil and gas industry workings. Thus, it can be said that AI adoption is still at a slow pace in the oil and gas industry owing to a lack of skilled manpower, political constraints, lack of internet interface, and security issues.

2.7. The transformation brought in the oil and gas industry with AI

There has been a 70% reduction in the oil prices since 2014 which has increased the concerns of the manufacturers around the world to adopt such measures that increase the efficacy of the industry at a reduced cost. AI application is highly useful for the oil and gas industry as it helps in quoting modules. AI-enabled tools will help in synchronizing the previous and current data and provide relevant information to the managers regarding predictive oil prices. If the process is performed manually, it would take hours to record data and establish a comparison between the previous and current data. There are chances of errors and mis-presentation of facts which may lead to wrong managerial decisions. However, AI-based analysis provides accurate and précised data in real-time which helps the managers to make rightful business decisions. Additionally, AI also provides asset management modules that help in recording resource data and managing them in reduced time. It helps in keeping employee safety, reducing fatality, and optimizing production levels. The AI application is also helpful in scheduling the functioning of the oil and gas industry by providing the options of Microsoft Excel, calendars, and whiteboards. It helps in scheduling equipment applications and managing crew members. AI implements predictive analytics and model predictive which helps in improving the overall performance of their facilities and more effectively maintain equipment. Thus, it can be said that the AI provides support to the different applications and frameworks and revolutionizes the oil and gas industry significantly ensuring high productivity.[11]

[11] **Hutter, F.; Xu, L.; Hoos, H.H.; Leyton-brown, K. Algorithm runtime prediction: Methods & evaluation. Artif. Intell. 2014, 206, 79–111**

2.8. Research Gap

As per the above-discussed facts, it can be said that AI is an innovative technology that helps in optimizing production in the oil and gas industry. AI helps in managing data, including geo map features, and enhancing sales analytics procedure. However, the positive aspects of the application of AI in the oil and gas industry have not been discussed by scholars previously as there is very limited data available regarding it in the academic literature. Therefore, the current study examined the different facts related to AI, its needs, and application in the oil and gas industry so that the gap that existed between the previous and current literature is filled. The study also examined the facts related to challenges that are faced by the oil and gas industry while implementing AI applications in the upstream, midstream, and downstream. However, the issues and challenges regarding the implementation of AI in the oil and gas industry were not discussed by scholars earlier that created a gap. The current research intends to fill the gap by providing relevant information related to challenges such as lack of skilled manpower, political constraints, lack of internet interface, and security issues faced by the oil and gas industry.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The present study is related to the role of artificial intelligence in the oil and gas industry. This study mainly focuses on the most popular application of artificial intelligence from the top five industries. It may be in the form of intelligent robots that are designed with artificial intelligence capability for hydrocarbon exploration and production so that it can improve productivity and also be considered as cost-effective by reducing worker risk. Three major operating sectors of the oil and gas industry involving upstream, midstream, and downstream. Applications such as quality control, prediction planning, and predictive maintenance for upstream, midstream, and downstream are majorly using AI which has been implicated in this study. AI includes many methods and continuously evolving range of technologies, as well as the following major subfields like Machine learning (ML) , Natural Language Processing (NLP) and Deep Learning (DL) which has been illustrated in this study for better understanding of the topic.

Various studies have revealed that the understanding of ideas and theories adopted regarding the research study is necessary for conduction of any research along with other motivational implementation. Hence, the research methodology has been considered as the most relevant section of a research study. Research methodology consists of the protocols that require the information regarding the research study according to the selected topic. This chapter illustrates the research methods that are being implemented in the current study for analyzing the results. The research study is entirely dependent on the research methodology for fulfilling the major aims and objectives of the study. Also, the research methodology has analyzed the appropriate interpretation of the study (Bernard, 2011). This chapter explains the associated sections such as research paradigm, research design, sampling techniques implemented, methods for data collection, techniques used for interpretation of data, and the ethical consideration of the research.

3.2 Research Paradigm

Research Paradigm has been considered to be the combination of different concepts, variables and all other issues concerned with the methodology approaches and all other related

tools in the research study. It consists of the structure or framework of the scientific ideas in the research study along with the values and assumptions being used in this study. The versions of paradigm has been explained by the researcher in terms of sharing beliefs that have been responsible for influencing the variety of knowledge gained by the researcher and the methods of interpreting collected information (Morgan, 2007). The reachers have also implicated the explanation of some of the paradigms for better understanding of the research paradigm. The basic concepts of Ontology have been revealed by the researchers that clearly implicates the paradigm types that evolve the determination of the reality and has been classified as positivism and interpretivism.

3.2.1 Positivism

Positivism has been considered as one of the most primary forms of research paradigm that has been evolved by analyzing the result through the scientific methods (Chilisa & Kawulich, 2012). This research paradigm was initially evolved during the 19th century when one of the researchers rejected the metaphysics in terms of research that may follow the scientific and logical reasoning for analyzing the research hypothesis.

The productive approach of positivism has been determined by analyzing the experiments, collection, observations, data analysis that involves quantitative estimation. It has been effective in inferring the connection among the variables along with the collection of the desired information and testing of the hypothesis. The researchers following the positivism concept eventually adopt the statistical method for data analysis (Yanow & Schwartz-Shea, 2015). It has also been analyzed that positivism is evolved from the concepts of science. Hence, it all involves the scientific fact for studying human activities.

3.2.2 Interpretivism

Interpretivism has been considered to have little variance with positivism that considers the beliefs and ideas. Many of the research studies have revealed the fact that interpretivism has been adapted by the researchers and has evolved the identification of the problems along with their solutions by observations collected from the ideas and meanings of humans. It has been reported by many researchers that interpretivism helps in analyzing the result by determining the social world and taking opinion of the individuals through the individual's actions analysis. The

interrogative methods have been used by the participants who are responsible for the collection of opinions and information for interpretivism methods.

The present research study has used interpretivism as a research paradigm for interpretation of the appropriate results. This result paradigm helps in analyzing the different parameters for fulfilling the major objectives of this research study by involving interrogative methods for the collection of opinions and information from the participants.

3.3 Research Approach

The research process follows a systematic protocol for fulfilling the major objectives by appropriate management of data procession and obtaining appropriate results accordingly. Also, it has been illustrated that the research process is only initiated when a certain question arises in the current process regarding the basic concepts and existence of the study. Hence, these questions evolve the initiation for conducting the research and identifying the solution to the research questions leading to adapting the research approaches. The research approaches are of three types which includes quantitative, qualitative, and mixed approaches. Hence, the adoption of the desired research approach is dependent upon the demand of the research (Williams, 2007). Therefore, it has been revealed that the basic aim of any research approach is to implement an appropriate strategy involving the methods of data collection, analysis of the collected data and its interpretation. A research approach is further divided into different categories represented below as:

- Data collection approach
- Data analysis or reasoning approach

3.3.1 Data collection approach

This type of research approach is further divided into three types which includes quantitative, qualitative and mixed approach.

- **Quantitative research approach:** This type of research approach has been basically evolved for quantifying the collected data in the research study. This research approach has been mainly implemented for establishing correlation among the different variables being used in the research study mainly involving the elements grouping, numbering and their conversion into the measurable models.

- **Qualitative research approach:** This type of research approach has been considered as the subjective one that involves comprehensive research with some sort of new theories (Jackson, 2015). It has been usually implemented in different modes such as through case studies, analyzing the content and determining the root theories (Williams, 2007).
- **Mixed research approach:** The researchers have found issues regarding the implementation of any of the above mentioned research approaches and this led towards difficulty in deciding the best suitable approach to be implicated that justifies the major objectives. This approach has involved the implication of different data collection in the research analysis with quantitative or qualitative data.

The present research study has followed a mixed research approach. The qualitative part consists of analysis of publicly available case studies and the quantitative part analyses work done by author and their team for company X.

3.4 Research Design

The design of research design has been considered as the complete set or plan carried out for the research work that have been combined together for performing the research in logical manner (De Vaus, 2001).The research design has been also considered as a blueprint in the research that involves the collected data, data evaluation and data analysis. The research design has been efficient in analyzing those data that are involved in obtaining appropriate results for the research study. The research designs have been developed in different forms that include descriptive, explanatory, exploratory and experimental (Salkind, 2010). These have been elaborated below:

3.4.1 Descriptive research design

The descriptive research design has been considered for providing an overlook on the research process being independent. This type of research design has been evolved in justifying the current practices along with the formulation and development of new theories accordingly (Yeboah-Fofie, 2017).The theories developed from this type of research design evolve interconnection among the existing variables involved in the research study and also acquire a descriptive method for the acceptance and rejection of the formulated hypothesis.

3.4.2 Explanatory research design

This research design has been defined as the development of casual relationship among the variables present in the research study. This type of research design first formulate the hypothesis and later the research methods such as data collection and all are carried on. Hence, here the collected data is completely dependent upon the developed hypothesis (Creswell & Clark, 2007).

3.4.3 Exploratory research design

This type of research design has evolved in exploring the matter for understanding the concept of the matter related to the research in a better way (Ariga, Hill & Ji, 2007). It has been also revealed that the primary objective of this research design aims in identifying the issues and variables for the research being studied. It also involves the research study with background of literature review and group interviews being conducted. Its theme has supported the research study in finding out the solution to the research problem.

3.4.4 Experimental research design

This research design has evolved for defining the formulated hypothesis and supports the development of valid inference that eventually considers the interrelation among the dependent and independent variables in the research study. The problem statement is first analyzed and depending on this, the hypothesis is further formulated. After the analysis of the data is done to obtain the final result which determines experimental design in the research work for representing the relationship among the different variables involved in the research study.

In the present study, descriptive research designs have been selected as the current practices have been used for developing new theories accordingly. Also, the process of data collected is initiated first and may be the formulation of research hypotheses is implicated later.

3.5 Data Collection Method

Two main sources of data collection have been involved in a research study that is primary data collection and secondary data collection that fulfills the major objectives of the research study (Maxwell, 2012).

3.5.1 Primary Data Collection

Primary data collection method has been considered as one of the most major types of data collection techniques that aims in gathering important information by using different methods. It has been used preferably in descriptive or experimental research design where relatable

experiments are being performed and the observations are done with analysis of communication sources such as conduction of survey process accordingly. Qualitative and quantitative research methods are involved in primary data collection.

3.5.2 Secondary Data Collection

The secondary data collection method is the type of data collection method that utilizes secondary sources for collecting data for conducting the research study. It involves the data with collected information from the previous studies that has been already performed by the researchers. Hence, this type of data collection majorly involves the accumulation of important data that helps in formulating a detailed knowledge regarding the study (Padgett, 2016). It is usually conducted by using resources such as articles, journals, websites, books, etc. that already exist as per the selected research study.

The present study involves secondary data collection which have been published by various researchers while the primary data is collected from the observations of the problem. Primary data can be gathered by applying either of the two basic research methods, qualitative or quantitative.

3.6 Data Analysis and Interpretation

The collected data is analyzed for obtaining results and making the objective of the research study quite clear. The data analysis tools are used according to the type of collected data.The qualitative data analysis uses the interpretations of the humans with the application of thematic analysis and content analysis techniques for interpreting the data by survey process through conduction of interviews (Panneerselvam, 2014). On the other hand, quantitative data has been analyzed by using statistical tools because the information or data of quantitative research has been collected in the form of numerical values and have to be represented in the form of graphs and charts for better understanding among the readers. Also, some software based tools such as SPSS, MS excel, graph pads, etch have been used for analyzing the quantitative data and evaluating the results. Thematic analysis has been also used in some of the studies that involve data coding according to the themes. Some of the statistical data analysis tools are illustrated below:

- **Chi-square test:** It is the type of statistical analysis tools that determines the correlation among the categorical variables according to the research study.
- **Correlation:** This type of data analyzing tools have been used for identifying the linear relationship among the distributing interval variables (Punch, 2013).

- **ANOVA:** This type of data analysis tools has been used for determining the variations and testing the hypothesis being developed in the research study. It evolvesa meaning that two people or more are equal to each other.
- **Factor analysis:** This type data analyzing tools have been used for exploratory analysis and often obtains relationships among the different variables being used in the research study (Ritchie et al., 2013).
- **Descriptive analysis:** It is the type of data analysis tool that involves the statistics and description of the common characteristics of the collected data. It basically involves the simple graphical representation of the data while summarizing the samples and measures.
- **Linear regression:** This type of data analysis tools have been helped in determining the interval outcomes and predictors.
- **Multiple regression:** This type of data analyzing tools have been used for predicting only one variable in terms of an equation and has been found similar to simple regression.
- **Thematic analysis:** This type of data analysis has been used to analyze the qualitative data. It has been mainly involved in the data collected in the form of interview transcripts.

In the present research study, the data analysis has been done by choosing the case study analysis which has been conducted manually.

3.7 Ethical Considerations

The ethical consideration in any research study has been considered to be an important process while implementing a research work. This process involves a set of rules and regulations that have been used in the completion of the research work in an ethical manner. It has further involved an appropriate standard while carrying any research work. The ethical consideration in any research work involves the permission and will of the participants and the participants are not supposed to be forced to attempt the questionnaires (Tashakkori & Teddlie, 2010). Also, the security and privacy of the data should be ensured so that no third party should not be able to access the data. Hence the present study has involved the clear concept of the ethical consideration by maintaining the privacy of data and protecting it by eliminating the data access to the third party. Also, the participants who actively responded to the survey have not been forced to participate and have shown their willingness to get indulge into the research study.

CHAPTER 4 CASE STUDY ANALYSIS

4.1 Case Studies in Public Domain

This section contains two case studies available in public domain which have been qualitatively analysed by the author.

4.1.1 Case Study 1

China Petroleum and Chemical Corp. (Sinopec)

Summary

China Petrochemical Company, founded as the Sinopec Group, integrated with Huawei to establish the concept of smart business units and an intelligent development network. Based on data gathered, AI may assist in streamlining the processes of chemical reaction by altering the volumes for catalysts, crude oil, and fuels, required for the process of refining. Four business units are currently as Smart Factory 1.0, which have resulted in an improvement of 10 percent in job efficiency. Smart Factory 2.0 is being developed integrating the AI framework to combine data and rationalize operations.

Context

"China Petrochemical Corporation, more generally termed as the Sinopec Group is a leading oil and chemical firm in China. The Global Fortune 500 list displayed it at third rank within the list of the entire industry in 2017. The Sinopec Group launched its smart plant projects in 2013, choosing certain pilot smart factories namely; Maoming, Yanshan, Jiujiang, and Zhenhai companies."

Project

The developer for the construction of these smart pilot factories is Petro CyberWorks Information Technology company Limited (PCITC), which is a joint partnership between the Pacific Century CyberWorks Limited (PCCW) and the Sinopec Group. In order to render smart plants in reality, PCITC selected Huawei. These Smart Business units generally utilise machine learning and big data powered techniques. Such innovations help in improving the cycle of processes of chemical reactions during the processing and development procedures by

collecting the information pertaining to production and refining. Optimum efficiency at lowest energy usage and without compromising on oil content are the resulting advantages. Moreover, experiential models for maintenance, operations and running of equipment are developed. Such models help track the status of the instruments in real time and forecast irregular machine condition, lowering maintenance and operations expenses and minimizing the chances of unplanned downtime.

The four established pilot smart business units already show impressive performance and account for the Sinopec Group's Smart Factory 1.0. The rate of use of advanced automation systems in the four pilot smart factories has been enhanced by 90%; the rate of automated data processing in development is over 90%; and all sources of pollution are controlled automatically. Optimization of output scenario was earlier applied on only certain processes and that too in offline mode. Although, it has now been applied to all processes and carried out in on-line mode. Both these changes boost production and enhance output and also the performance of labour was found to be increased by more than 10%.

Throughout the oil and petrochemical sectors, ICT offers measurable advantages and allows increased returns on investment (ROI). The main advantages include enhanced higher rates of recovery of oil, production-to-consumption levels, greater labour efficiency, long-term reliable plant management, and lowered maintenance costs.

In April 2017, Huawei and PCITC mutually unveiled a digital development framework that was not only the first big collaborative project of both companies after strategic alliances were established; it was also the central component of the Sinopec Group's Smart Factory 2.0 initiative. The eight key features of this network are: unified development, IoT connectivity, IT management and regulation, optimisation, specific applications , data collection and interpretation and Artificial Intelligence. The framework should become a smart production 'benchmarking operating environment.' Within this smart development process, latest ICT innovations such as IoT, cloud, Virtual Reality, machine learning, and Big Data are also implemented. It is planned to become a leading smart development network in the process-centered sector.

This AI-capable framework institutionalizes laws, templates and information, and generates an intellectual brain through the use of deep learning and thought data for petrochemical plants.

4.1.2 Case Study Analysis 1

The dramatic rise in AI research in recent years has demonstrated that almost every discipline has a capacity to be a forward-looking orientation. AI development is definitely an excellent platform in the oil and gas sector as well, drawing interest from academics who are interested in it. The introduction of AI is critical for oilfield technology problems, including the complex prediction for oilfield output, the optimisation of the strategy, identification of the residual oil, detection of fractures and improved oil recovery (Li, et. al., 2020; Lu, et. al., 2019). The current case study discusses the case of China Petroleum and Chemical Corporation (Sinopec). Here, the Sinopec Group has joined hands with Huawei in order to introduce smart factories. This concept of smart factories is based on the introduction of Artificial Intelligence for streamlining the process of chemical reaction. It works on the principle of collecting data and then appropriately adjusting the volumes of fuels, catalysts and crude oils for the process of refining. Currently, four factories are established by the Sinopec group as Smart Factory 1.0 which has helped in improving labour productivity considerably. Further, the Sinopec group is looking forward to developing Smart Factory 2.0 which will serve as an AI powered platform aiming to centralise operations and integrate the data. To build the smart factories, a joint venture of the Sinopec Group and Pacific Century CyberWorks Limited has been launched named as the Petro-CyberWorks Information Technology Company Limited (PCITC). These factories will use Big data analytics and machine learning technologies. In the downstream and upstream oil and gas industry, big data analytics has emerged as a recent trend. Big data analytics refers to a modern technology that manages massive datasets with 6 major attributes namely variety, volume, complexity, value and veracity. In recent years, the oil and gas sector has been turned into an extensive data-intensive sector with the introduction of data capturing sensors in production, drilling and exploration processes. Many of the Big Data implementations in the petroleum and gas industries include monitoring microseismic and seismic results, advancements in reservoir simulation and characterization, maximizing output pump efficiency, reducing the time taken for drilling and ensuring safety related to such activities, improving petrochemical resource management, better transport and shipping as well as improved industrial health (Mohammadpoor & Torabi, 2018). Moreover, the latest strategic aim for increasing market value in the oil and gas sector is to digitize workflows through artificial intelligence and advanced analytics. Industries aspire to adopt emerging innovations, but are struggling to get their ideas into action to achieve measurable outcomes to earn attractive

investment returns (Hajizadeh, 2019). In the present scenario, such techniques are used by the Sinopec group to gather information regarding production and refining and accordingly adjust the volumes of crude oil, fuels, and catalysts necessary for the refining process. The benefits of this technique are that it provides optimal productivity by using minimum energy and also does not compromise the quality of the oil produced. Moreover, AI modes are also set up for Operations and Maintenance which assist in monitoring the real time data, predicts any abnormal functioning, avoids risk of downturns, thus reducing the Operations and Maintenance costs. The results corresponding to the four established Factory 1.0 are remarkable. The use of advanced technology, the automated data collection techniques and the automatic detection of the pollution sources are the key features of these factories. Also, the optimization of production is extended to all processes and is done digitally. All these advancements have proved to be significant in terms of enhancement of labour productivity, thus contributing to higher efficiency and better quality. Apart from these, other benefits include maximizing Return On Investment, higher oil recovery rate, enhancements in production to consumption ratios, better employee productivity, lower operating costs and improved stable equipment. The concept of Smart Factory 2.0 is an innovation pertaining to the Joint venture of PCITC and Huawei. The imperative capabilities of this platform includes Centralized integration, IoT access, IT management and control, optimization, shared services, data processing and analysis, and AI. It also integrates ICT technologies like cloud computing, the IoT, Big Data, Virtual Reality (VR), and machine learning. It aims to highlight the concept of Smart Manufacturing.

Each industry will profit from artificial intelligence and the same applies to the oil and gas industry. This is one of the most dangerous and lucrative industries. Intelligence optimizes sales, efficiency and ensures safety. The productive usage, along with a clear knowledge of conventional statistics, data mines, artificial intelligences and computer education, of data-driven approaches involves thorough comprehension of oil production processes and physical methods. The AI approach to finding problems and remedies starts with a data-based methodology. Although the AI approaches provide fantastic solutions to complicated and complex processes that are unique and challenging to describe using traditional conventional methods, the sector is still dubious about the usage of this approach. The delicacy and responsiveness of the systems and the utilization of data are closely related to this. Data management and optimization are core components of an efficient AI operation (Balaji, et. al, 2018).

4.1.3 Case Study 2

Royal Dutch Shell PLC

Summary

In order to avoid downtime and increase quality and performance Shell is utilizing Microsoft and C3 IoT technologies. By forecasting the maintenance needs of the appliances such as valves and compressors, the organization will benefit from the project. The two projects under construction include upstream facilities for the processing of coal seam gas and the identification of abnormalities in the functioning of downstream valves.

Context

"Large petroleum companies such as Shell seek to reduce costs , improve output, and control properties more effectively by best utilizing data that flows from both field equipment and corporate structures."

Project

'Royal Dutch Shell PLC uses a modern technology artificious network to help its predictive maintenance activities and extend AI driven software throughout the enterprise.

Yuri Sebregts, Chief Technical Officer and Executive Vice-President of Shell, tells CIO Report, that in order to render machine learning and other technologies more prevalent in Shell, it is imperative to design and implement AI applications at large scale. Shell will utilize Microsoft and C3 IoT technologies to anticipate when valves, compressors, and other devices need to be maintained; also it will aid in guiding bits around shale reservoirs; and boost workplace health and consumer protection. Shell utilizes artificial intelligence resources from Microsoft, specifically Bonsai, which were bought earlier this year. These technologies develop softwares to enable computers to work independently.

According to Shell, AI-enabled horizontal drills help to increase reliability and minimize drill wear and tear through real-time data from the drill bit, this aids geologists to track it more accurately.

The technology is going into production for two predictive software applications. In Australia, the first requires upstream facilities to process coal seam gas. Secondly, anomalies of downstream valves are observed.

The analytics and other techniques help Shell in forecasting when the equipment would fail and thus the fixation of the instrument can be done before it completely shatters. This will eventually help in preventing the assets downtime which will lower the costs and boost efficiency.

4.1.4 Case Study Analysis 2

Petroleum industry is a critical engine for the growth of an economy. Maintenance can be defined as a procedure done on an equipment, to ensure that it performs the functions appropriately. Maintenance is vital to the success of the oil sector because of its importance in the fields such as profitability, productivity, reliability, environmental preservation, quality, safety, regulatory compliance and system. Advances of technology have contributed to an significant role for Artificial Intelligence in the operation of every business. The application of automated programs to do research involving human comprehension requires artificial intelligence (Mushiri, Hungwe, & Mbohwa, 2017).

The current case study deals with the Royal Dutch Shell PLC, which is also known as Shell. This company is Anglo-Dutch multinational oil and gas company headquartered in the Netherlands and incorporated in England. It is one of the oil and gas "supermajors" and the third-largest company in the world measured by 2018 revenues (Raval, 2019). This case study is dedicated to the application of AI in the oil and gas industry. In order to enhance its productivity and efficiency and to prevent downtime, Shell has adopted technology from C3 IoT and Microsoft. The application of Artificial Intelligence will help in predicting the need of the equipment like valves, compressors and also maintenance of the machinery involved. Primarily, the company is using Artificial Intelligence in the production and innovation of equipment for Coal Seam Gas production and to detect any issues in the downstream valves.

Basically, major oil producers are shifting towards the implementation of AI inorder to reduce expenses, improve productivity and ensure the efficient management of the assets. Due to the advancement in technology, such as high-resolution sensor variability and device processing, a broad variety of data from oil fields can today be obtained. Oil engineering utilizes these data to track the activity of the petroleum development fields to ensure the lowest possible output volume (Marco, et. al., 2019). Royal Dutch Shell PLC aims to utilize the AI platforms in order to direct its

efforts towards predictive maintenance. The technology team is making immense efforts to introduce AI in almost every operation of the company. Basically AI will help in predicting the need for maintenance of equipment, valves and compressors, assist the steer drill bits through shale deposits and improve the safety concerns regarding the customers and the employees. Further other AI tools are adopted by Shell from Bonsai that develops softwares for running the computers autonomously. According to Shell, AI-enabled horizontal drilling efforts that allow geologists to track a more accurate path in real time will improve to be efficient and reduce the wear and tear of the drill. Shell can step in and fix the equipment before it breaks by utilizing analytics to predict when equipment will fail. This will avoid unplanned downtimes, thus lowering costs and boosting efficiency.

The case study highlights that Shell currently uses AI for production and detection of the anomalies. However, the technological team is further trying to implement AI into other fields too. This will help in improving the operational efficiency, reduction of costs, predictive data intelligence, better safety measures and exploring new resources. The AI technologies like Big data analytics, IoT, machine learning, NLP can be applied to the Oil and Gas Industry in various activities like drilling, production, reservoir management, chatbots, monitoring and automation. The advancements and innovation in this field will prove to be a boon for the Oil and Gas Industry (Noshi, Assem, & Schubert, 2018).

4.2 Case Study 3

This section summarizes use of simple AI and predictive analytics by author and team for downtime reduction in company X

4.2.1 Objective

The aim is to use Simple AI algorithms for predictive analysis and reduce unplanned downtime for company X

Many petroleum companies seek to reduce cost and increase uptime through early warning of valve failure as valve replacement is a major capex and opex cost to most of the petroleum companies. The valve maintenance is mostly time based analysis too early prediction can lead to unscheduled deferment while too late can lead to scheduled deferment of production. A single

control valve failure in a refinery led to a million $ loss due to maintenance costs and production losses. Losses of this kind can include the costs of both clean-up and asset downtime. With over 20,000 control valves in a single refinery and over 1 million in total, the company looked for proactive ways to discover and mitigate failures before they become catastrophic.

Obtaining this type of actionable valve health information requires a reliable predictive monitoring system with the application of Artificial Intelligence (AI), that estimates the health condition of each valve and determines the early signs of degradation to diagnosis the problem.

4.2.2 Methodology

For this particular case study and research, there was a huge primary data collecting from various sources like refinery operating systems, process parameters, transmitters reading , valves datasheets , information from control systems, databases, plant applications, and operation procedures. etc. the collected data was systematically organized for better utilization considering various aspects like process upsets , out dated data and other filters in place for collecting cleaning. The cleansed data was modelled using the ML algorithm using the machine learning and predicative approaches. This algorithm results on analysed by the tool to provide insights into the actual behaviour of the valves and failure prediction rates. This analysed data was forecasted for along with alerts in various systems like SAP system to indicate that an action is required before there is valve failure. This philosophy of monitoring the system also aligns with conditioning monitoring of various critical equipment's in oil and gas industry.

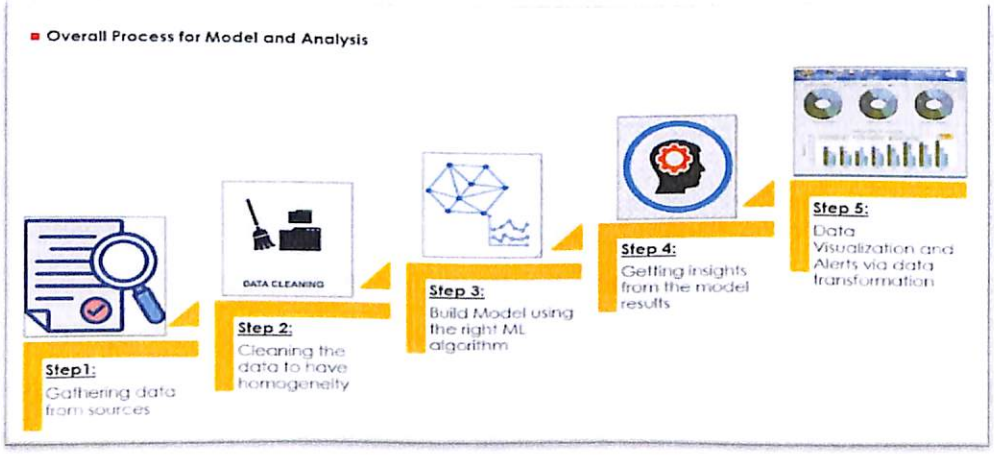

Fig 1: Process for Model Building and Analysis

Therefore in this study machine learning and predictive analytics approaches, were combined to build initial models in order to infer the valve health condition. The predicative model was wed base, C3 platform and OSi-Pi based. The model could produce the results for bulk data (ie. Valves) with minimum inputs with multiple algorithms for various process scenarios and filters. The analytic tool could auto classify the parameters, models and predictions from the model. The analytic tool combined with machine learning model could minimic normal behaviour, predict and detect abnormal behaviour. The complete data analysis is done in offline conditions which doesn't hamper the live running process of the refinery and provides continuous KPI or performance data to the Stakeholders. The backbone for the analytic tool is the automation which provides the platform for the integration of the data and analysis of the data. Automation provides the platform for the digitalization of huge amount of the data for the dashboard creation for the parameters which stand for company's KPI.

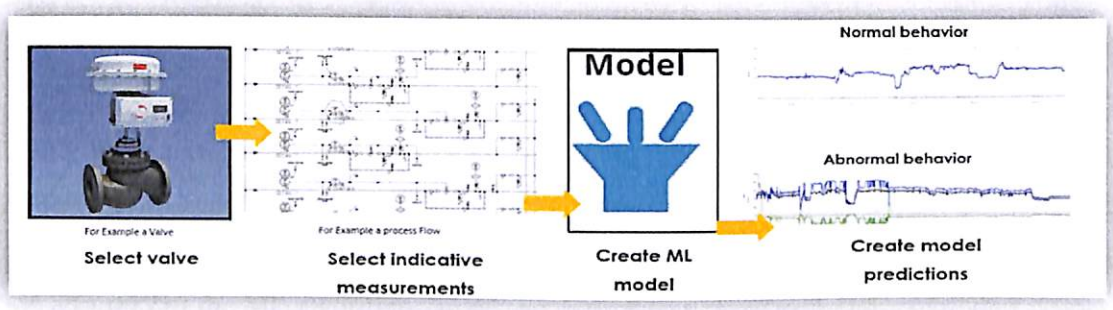

Fig 2 : Simplified Flow Chart For-Valve Predicative Analysis

The data was plugged into the ML algorithm, which brings together multiple features into a single health index that estimates the health condition of the valves. On a daily basis, the application receives relevant time series for every sensor that is from the control valve within an asset. After data loading and normalization is complete, the application triggers predictions of the expected behavior of the prediction target. Alerting logic determines whether or not the actual value received from the source system is within the range of allowed deviation from the prediction. If it is not within acceptable tolerances, the application raises an alert for the instrumentation engineer to troubleshoot. The condition of the valves are represented in the software by various colors while green indicating healthy when compared to the threshold value, while red indicated failure and

requires the immediate action. For better monitoring and proactive action, the tool would provide the alerts with action required and time limit for the actions.

4.2.3 Outcome of Model Run Studies

Results of this research has a large valve to company X it has great promise to deliver strong business value. An example of the solution is shown in figure below results from Model:-

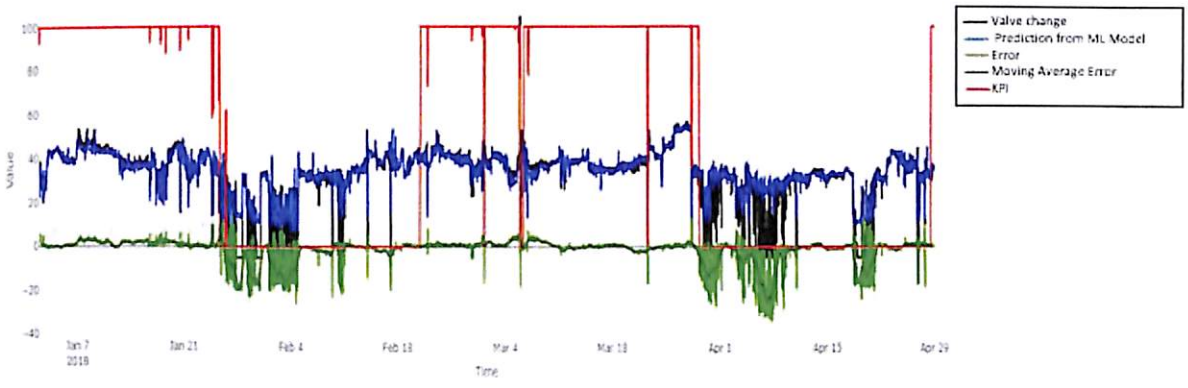

Fig 3 : Predicted Variance

The performance of the valve or targeted KPI is contributed to multiple variables extracted through pressure, position and signals health. In this example, the main contributing feature is position related issue which can be read through the readback signal, and this variable has a contribution of 55% accuracy of the ML algorithm..

MVP Results:

- MVP scale-up from 16 to 140, from which 70 can be predicted.
- Investigated Important notifications: 4 cases out of 6 were predicted
    - 70% of notifications are on valves that can be modelled while ~30% of notifications are difficult to be predicted

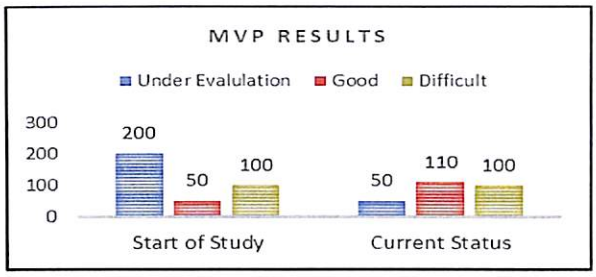

Fig 4: Statistics of Valves Attended

Various System Notifications generated based on the error between predications of the ML model and actual behaviour to the instrument team to take the actions. The issue of the valve is identified and generated by the systems. The colour indicates the action priority to be taken for the valve to reduce the maintenance cost.

Valve Number	Type of Notification	Detected by ML Model	Incident detected upfront of failure or maintenance activity	Number of days prior to failure	Notification on valve/trans mitter	Zone of Color
X1	Valve doesn't open	Yes	Upfront of failure	10	Valve	
X2	Valve in stuck condition	Yes	Upfront of failure	200	Valve	
X4	Stem broken	Yes	Upfront of failure	10	Valve	
X5	Valve doesn't respond to software	Not by system	Upfront of failure	11	Valve	
X8	Positioner faulty	Yes	Upfront of failure	10	Valve	
X9	Pneumatic system doesn't work	Not by system	In Maintainence activity	0	Valve	

Fig 5: System Generated Alerts

This guides the instrument team to inspect the position i.e. positioner related features and confirm the results of the health monitoring algorithms. Validation of these analysis methods with more field data like filter on transmitters, nonlinear behaviour of the valves etc is part of the planned future work. In this case study the AI technology was also used to predict and alert the instruments

for the action which results to cost reduction to the oil company. Fig 4 gives a summary of results from the study

4.2.4 Value creation highlights

Through this predicative or AI technology can ultimately lead to lower maintenance cost, less downtime, and improved operations for the end-user/process plant. This was witnessed by the tool itself which could provide the value created to the Company X using the data of 4 cases out of 6 cases stated above:-

	Min ($M)	Max ($M)	Average ($M)	Maintenance Costs ($M)
Historical Incidents	1	2.5	1.75	0.2
Newly detected issues	0.2	3.1	3.2	0.07
Grand total detections	3.6	10.3	6.9	0.6

Table 1 : Valve analytics – Value Creation Tracker

Therefore AI in oil and gas industry provides

- A comprehensive platform built with a model-driven AI architecture to enable rapid design, development and operation of AI and IoT applications.
- Platform can be expanded beyond Predictive Maintenance i.e. retail, supply chain, shipping and others.
- Suite of proven, extensible cross-industry applications to deliver predictive insights for critical real-time business challenges.
- Unified, secure model-driven architecture to enable users to rapidly access disparate datasets

Market standard solution will allow us to scale and replicate at a much higher velocity thereby enabling the businesses to realise the associated benefits earlier.

CHAPTER 5: INTERPRETATION OF RESULTS

The present study aims towards understanding the role of AI in the oil and gas industry. The advanced technologies of AI along with other technologies such as machine learning have increased in the oil and gas industry. Artificial intelligence (AI) has been considered to be an effective advanced technology that increases the capabilities of the machines. Hence, the present study implicates better understanding regarding the role of AI in the oil and gas industry by identifying the Application of a range of technologies in the industry. The transformation of the oil and gas industry operations have been revealed in detail.

This study involves the secondary data sources for the collected of data and the collected has been analyzed by analyzing the case studies. The China Petroleum Company was founded by Sinopec Group which was integrated with Huawei for establishing the clear concept of a smart business unit and an intelligent development network. This collaboration has resulted in the introduction of smart factories with the concept of AI introduction for streamlining the process of chemical reaction. At present, four factories have been developed by Sinopec Group which has evolved the development of Smart factor 1.0. Smart factory 2.0 has been planned for development which will be based on AI aspects for centralizing the operations and integrating the data. Big data analytics and machine learning technologies have been introduced for building the smart factories by a joint venture of Sinopec Group and Pacific Century CyberWorks Limited commonly named as Petro-CyberWorks Information Technology Company Limited (PCITC). Also, the use of the advanced technologies in the development of smart factories have evolved automatic detection of pollution which have been proved to be salient features of these factories. Hence, the use of AI as an advanced technique in these industries has provided optimal productivity by utilizing minimum energy with production of good quality of oil and maximum yield.

Royal Dutch Shell PLC has been also using advanced techniques such as Microsoft and C3 IoT for increasing the quality and performance of Shell and hence avoiding downtime. The projects have been looking forward to upstream facilities of processing of the coal seam gas and identifying the non-functioning of downstream valves. The applications of AI in this industry have evolved the requirement of improving the efficiency of the equipment such as valves, compressors and

other machineries. Hence, the AI platforms have been utilized by Royal Dutch Shell PLC for maintenance of the equipment and adopting safety concerns of the employees and the customers.

Similarly in the work done for company X, which can be extended to thousands of sensors , valves and equipment it is seen how predictive analytics can help assets save millions of dollars over a short period of time. This come in combination of reduced unplanned events and optimum distribution of preventive maintained resources.

Therefore the case studies have shown the applications of AI platforms being adopted in the oil and gas industries with all possible efforts for the growth of the industries along with proper maintenance. This utilization of AI in these industries leads towards the improvement of the industries for future competitiveness according to the fast-changing environment of this modern era.

CHAPTER 6: CONCLUSION AND SCOPE FOR FUTURE WORK

6.1 Major Findings

The present study aims towards the implication of the growing role of AI in the oil and gas industry.. The major objective of the study is to implicate the operational functions of the oil and gas industries utilizing the AI platforms with involvement of other advanced technologies for the growth and development of the industries. AI has been effective towards cost saving investment for the industry of oil and gas with improvement in the upstream, midstream, and downstream processes in the industry. The case studies have proved the major applications of AI which have been used by the industries. China Petroleum and Chemical Corporation (Sinopec) have collaborated with other companies which have contributed in the cost investment making the operational process to be cost-efficient and development of different smart factories by utilizing smart development process with the implementation of AI and other ICt tools such as IoT, Virtual Reality, Machine Learning and Big Data. These advanced techniques have resulted in a smart development network in the process-centered network.

Royal Dutch Shell PLC has been also using the modern artificious network for predictive maintenance of the activities and extending the AI driven software throughout the enterprise. The AI applications have been used in broad spectrum with utilization of Microsoft and C3 technologies for maintaining the equipment and other machinery in the industry. This helps in preventing the downtime that lowers the cost and enhances the efficiency.

Similarly company X is using simple AI and predictive analysis in helping reduce unplanned down time and optimizing production. Most of the models are developed in house or in conjunction with specialized vendors.

6.2 Recommendations

The above facts have clearly implicated that the applications of AI have been effective in the enhancement and growth of the oil and gas industries. Still some of the recommendations have been evolved for the study which has been illustrated below:

- The facts and features of AI in the oil and gas industry are less frequently revealed in the work zone and hence it is highly recommended to provide these facts to the other business leaders revealing the healthy overview of AI initiatives to make them aware regarding the use of AI platforms in their sectors.
- The growth of energy investment should be highlighted with detailed information.
- The information on the cost saving investment inherited by the oil and gas industries across the globe should be implicated in details so that the efficiency of using AI in this industry can be justified.
- The efforts for improving the working conditions of the employees are not clearly mentioned in this study. Therefore, the efficacy of AI in improving the employees' working condition should be implicated here.
- The smaller companies of oil and gas industries following the application of AI has not been illustrated here. Therefore, it is recommended to illustrate information regarding those companies using AI platforms in some aspects.
- Socio economic impact and academic shifts arising due to integration of AI in labour intensive industry like Oil and gas need to be studies in detail

6.3 Limitations

Following are some of the limitations that have been evolved from the given study:

- One of the limitations identified is that many of the small companies of oil and gas industries cannot afford the cost that is important for maintaining the business efficacy that utilizes AI platforms. The technologies of AI have been quite expensive and hence its maintenance needs investment with high cost financial support for which many of the small companies are not capable of holding.
- Regular upgradation of software programmes evolved in AI and other advanced techniques are needed according to the changes in the business environment. Hence, if the automated systems are not upgraded at a regular time interval, it may result in the loss of important data and coding. Hence, this requirement should be fulfilled to avoid the loss of data.
- Some of the issues such as customer privacy, lack of transparency and complexity in the process have been faced by many of the companies in oil and gas industries which need to be modified and checked for proper functioning in the operation activities of the company.

- AI will lead to potential job losses, academic shifts and the socio economic impact pf the same has not been studied in detail especially in case of emerging economies

6.4 Future research

The present study has implicated the facts and features of AI platforms being used in the oil and gas industries but still some of the aspects of AI applications in this sector have been missing and future work on the same is required for better understanding of all the perspectives of AI in the oil and gas industry. It is recommended to develop more research so that the understanding of using AI platforms by the small companies of oil and gas industries can be revealed. Also, the impact of AI on working conditions of the employees in this industry need to be carried upon in future research. Further, the author found limited work done on socio economic impact due to integration of AI in labour intensive industries like oil and Gas. This needs to be studies in detail especially focusing on situation of emerging economies and developing nations.

6.5 Conclusion

As seen various aspects of AI and its associated technologies is already apart of rapidly changing Oil and gas industry. Not everything is rosy about AI currently when it comes to Oil and gas. It still requires big pockets for R&D and implementation. Lack of trained and experienced professionals is also a challenge to be over come. A recent poll validated that 56% of senior AI professionals considered that a lack of additional and qualified AI workers was the only biggest hurdle to be overcome, in terms of obtaining the necessary level of AI implementation across business operations. Factors like these mean that foray into these technology exposes smaller companies to an amount of risk they may not want to take and in near term most of integration is going to come from big companies like Shell, Exxon and National oil companies from middle east. Once results are established other will follow suit. The people aspect with threat of job losses within the industry also needs to be over come. AI does not make brain redundant but helps in enhancing human capability.

Where does all of this lead into the future especially with the world increasingly shifting towards renewable energy? It is generally accepted that while in general by 2050 renewable energy will be a significant part of energy mix, Oil and gas sector will continue to play a major role in energy industry.

AI and associated technologies are and will enable people to make better informed, data-driven decisions resulting in lower cost, more safe and reliable assets and significantly better environmental performance. These technologies will help process data and create algorithms to solve multivariable problems much beyond the capability of the normal human mind.

The author can confidently say that integration of these technologies is already in process of dramatically improving the oil and gas industry and hence making the world a better place.

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