Benefits of Implementing Quality Management Systems in Exploration Drilling Operations - Global Perspectives

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Abstract

The study aims to investigate the advantages of executing a Quality Management System (QMS) throughout exploration drilling operations. The methodology used for this article is a review of articles published between 2008 – 2019 which addresses areas in exploration drilling and Quality Management. Numerous writers have expressed that certification is mainly accrued to allow transactions in global markets and to have access to the official vendor's list of potential clients. While other authors have discussed how the original interest to implement QMS is frequently followed by surprise and, occasionally, even by outrage, when the task team understands that the application of a quality control plan comprises several undesirable adjustments of the budget allocated to the exploration. The paper analyses what benefits are there in implementing QMS through exploration drilling operations and what implications organizations that have not implemented this system have undergone.

Keywords

Quality Management System (QMS), Exploration Drilling, Mineral Exploration, Mineral Processing.

1. Introduction

1.1 Background of the Study

The objective of exploration is to search for economic natural resources deposit via numerous stages and to decrease the organization's risk. The natural resources characteristically not exhaustible that implies that they are finite in terms of time and quantity available for mining. With the expanding count of natural resources which have been explored and mined, to explore new mineral will become difficult. Commonly, the natural resources which are situated close to surface as well as which are worth high monetary value had been found and exploited (Setyadi and Anggayana, 2013). Exploration drilling currently is challenging as more minerals are covered by climate and soil and outcrops or some other concealment. Only matured exploration approaches are essential to discover them. The explored resources are referred to as a mineral deposit such as coal, gas, oil, or water (Haldar, 2018).

To discover or explore these minerals, drilling techniques should be employed in terms of a reputable outsourcer to offer this critical service. Drilling is an extremely costly process requiring substantial heavy machinery and advanced methods (Akin and Karpuz, 2008) and various risks are related to such operations. The most essential outcome for exploration drilling is the core extracted from the process (Heinz, 2008). Drilling rigs are operated by numerous customers globally with a mutual goal and operating system which is known as outsourcing. The client will be outsourcing the extent of activities to professional drilling contractors to execute the drilling project as agreed in the agreement by which the service provider will be delivering the drilling rig with its associated equipment plus staffs to run it (Harthy et al., 2018).

1.2 Exploration Project Circle

According to Haldar (2018), there are nine stages to a typical mineral exploration project cycle. These stages have been explicitly detailed in the literature, however, as depicted in Figure 1, this paper elaborate briefly on each of the stages: (1) ***Mineral Exploration***: The initial phase of mineral exploration includes a study and evaluation of accessible remote detecting and photogeological data leading to selection of convenient areas, followed by field investigation, therefore, land attainment, possibly proceeding to geophysical surveys, geological mapping and prospecting, geochemical and geophysical surveys, and drilling. (2) ***Feasibility Study Phase***: If the first phase is successful this will give guidance to explorers whether there could be a feasible project that can validate the cost of progressing to a feasibility study that will be coordinated for test work and sampling, mineral investigation of the ore, and pilot plant

testing to determine the feasibility of selected mineral processing and retrievability of the ore, drilling, mineralogical, assaying and pilot plant testing will commence. (3) ***Mine Development Phase***: If exploration results are positive the project will move to the mine development phase. This phase specialists will evaluate the discovered materials and their value and life span and the success of the investigation a mine will be developed. (4) ***Extraction of Mineral Phase***: Two types of primary mining techniques exist which are surface mining and underground mining. A single mine may employ both methods. Machinery mostly known as drill rigs can be used to extract minerals from selected exploration areas, blasting can also be applied. (5) ***Mineral Processing***: the first method used in metallurgical processing is core sample testing the process has proved that cyanide leaching as one of the most cost-effective techniques of extracting gold from low-grade ore. Extracted ore is transferred on to an ore surge pile and a primary jaw crusher fed into a two-deck vibrating screen and to a densifier/Agglomerator. The second stage of mineral processing includes compressing large-sized ore through a cone crusher in a parallel circuit, the core is then sampled and weighed. (6) ***Smelting***: This method usually not applicable to mud rotary drilling (oil and gas), it includes removal of metal from metal in a liquid state. (7) ***Refining***: a this phase the product is purified and ready to sell or ship to the next party. (8) ***Marketing***: Shipping of the actual product to the buyer or customer. (9) ***Closure***: Closure and Rehabilitation phase this stage is based on the results of explored areas this stage determines whether further exploration of the area is required or a need for rehabilitation. Once the ore material is depleted or technologically or economically becomes unreachable, the mine shuts down.

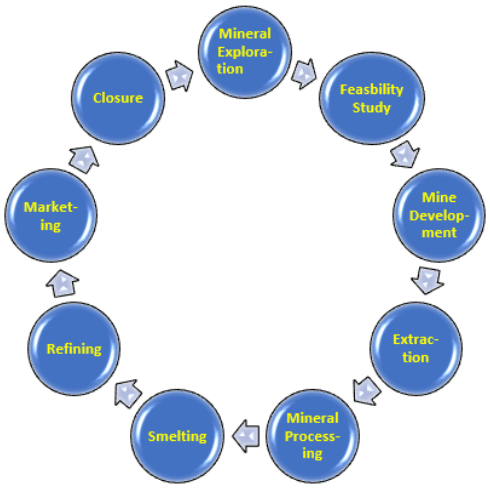

Figure 1. Mineral Exploration Phase

Before the mineral processing stage, a sample is collected from the contracted company and the quality of the data given will be scrutinized for any anomalies through analytical methods and statistical interpretation. To emphasize this point before commencing to the processing stage the quality of data received from the contractor after extraction is vital. Data generated from this type of project should be correctly stored and proper quality control procedures should be implemented as stated by Haldar (2018).

1.3 Rationale, Scope, and Limitations of the Study

The perception of "quality" has evolved to signify much more than simply the dependability of a fabricated good. Quality nowadays implies a thinking, a structure of practices and procedures, and an ongoing responsibility to enterprise superiority that incorporates all important subjects and involves all objects within a business. Organizations define quality differently, whether they are private, parastatals or government, the definition depends on the organization's QMS viewpoint. The term quality, although it has evolved over the past decades, describes what satisfies the customer with regards to what he/she paid for a service or a product (Kumar, Raju, and Satish Kumar, 2016). Exploration drilling is one of the vital activities employed mostly in the mining, oil and gas sectors to ascertain the life span of a geographical area. However, exploration drilling operations have more of their focus on safety processes and implementing safety systems to decrease Lost Time Injuries (LTIs) through the industry, understandably so since mining is viewed as a high-risk occupation as highlighted by Paul (2009). It has been proven that the decrease in LTIs is due to three aspects: enhanced equipment, safety systems and culture (Henson, 2013).

Through the global perception, most authors are silent with regards to completely implementing QMS through exploration drilling industries. Global standards change frequently, hence the mining industries must be innovative to excerpt value on the projects. It is with no surprise that basic quality control processes are still poorly understood, misemployed, leading to constant misperception in the exploration and mining sectors and drilling exploration (Sterk, 2015).

1.4 Aim, Objective, and Value Study

This report aims to investigate the benefits encountered when implementing QMS through the drilling exploration operations on a global perceptive and why there is still uncertainty in the market to implement QMS through this industry. The study is carried to rationalize the significance of implementing QMS as part of integrated management systems through exploration drilling operations and the various ways an organization can benefit from implementing QMS.

2. Literature Review

2.1 Evolution of Quality

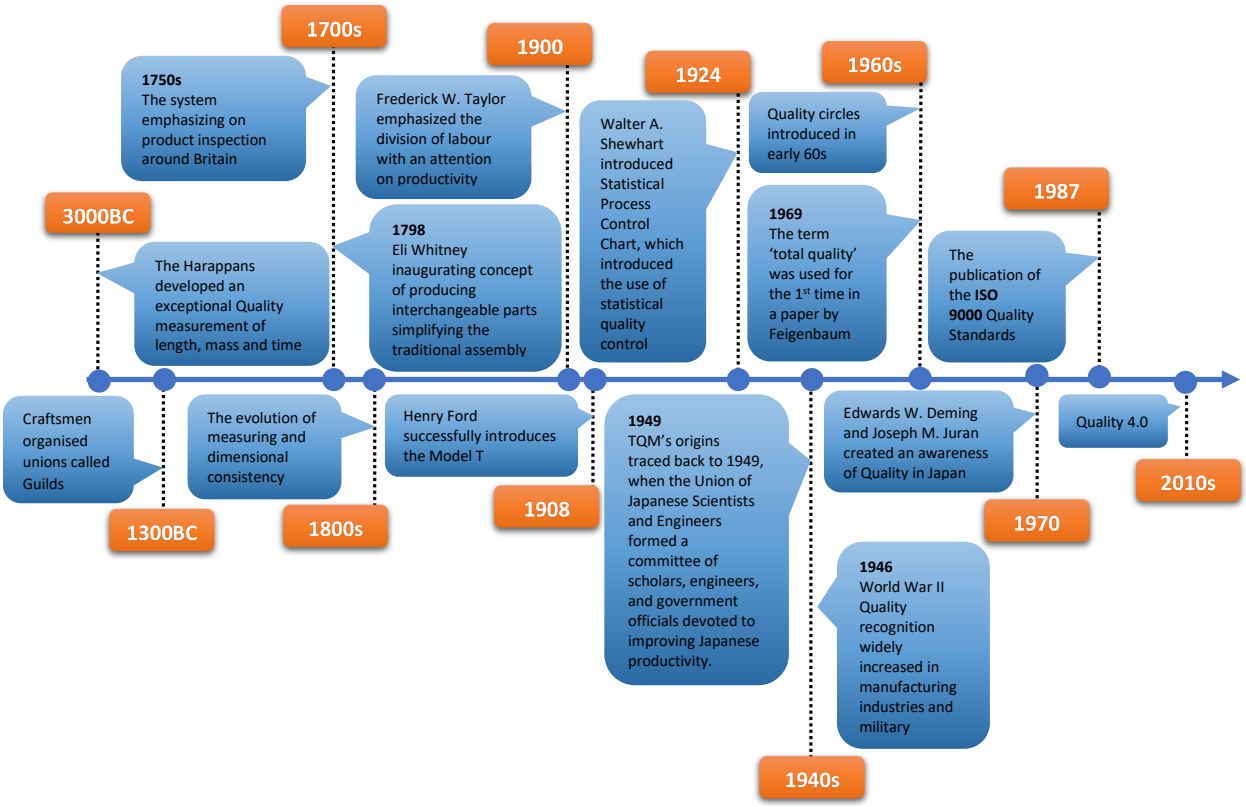

Figure 2. History of Quality – Timeline

The word "Quality" is derived from old Latin and French "*Qualité*" which denotes "of what sort" describing the object's physical form or nature (Hoang, 2017). Shown in Figure 2 earlier, quality management has been employed throughout ancient history, as far back as 3000BC when the Harappans implemented some forms of quality management through the development of Lothal by creating measurement of length, mass and time (Chandrupatla, 2009). The maturity of quality went on during the 13th century when the craftsmen implemented the Guilds union trade model which assisted in meeting customer needs and requirements (Forster, 2013) through the transmission of knowledge within extended families or clans (de la Croix, Doepke, and Mokyr, 2017). In the 18th century, this model was adopted by manufacturing industries. Eli Whitney an American innovator and quality pioneer introduced the notion of interchangeable parts assisting production with minima product variation and ordered integrated flow (McGregor et al., 2002; Hazarika, Dixit and Davim, 2019; Hodges, 2019; Smithurst, 2019). With an increasing amount

of contention and inefficiencies in the 1900s, Frederick Taylor established management scientific principles that are still applied today (Vijai et al., 2017; Ireh, 2016; Chang, 2016). A study was conducted at Bethlehem Steel, this study included the formulation of wok instructions, pre-task planning, these activities were conducted by not only employees but also management involvement was a focal point (Hoyle, 2017). Henry Ford's introduction of the automobile in the early 1900s required more reliable parts which did not harm the production assembly his influence on the quality world was the introduction of assembly line that consisted of workstations that had various tasks assigned to them (Rycroft, 2017; Kucan and Switzer, 2017). Walter Shewhart who has been coined the father of Statistical Quality Control, defined quality as the goodness of the product, and is recognized for having developed Statistical Process Control (SPC) to regulate the variation in processes by recognizing the cause and removing it from the process in the 1930s (Rao, 2015; Bradford and Miranti, 2019). Between the 1970s and 1980s, Deming and Juran teamed up to form awareness and a series of lectures in Japan which changed the manufacturing industry, and the application of these lessons increased the Japanese market share in the American Markets (Chandrupatla, 2009).

2.2 Overview of Quality Management in Drilling Exploration

In the past 30 years, numerous companies around the world have incorporated the ISO 9000 standard as their mission for improving their organization's performance and customer satisfaction. Regardless of having been globally recognized and broadly acknowledged since its publication in 1987, the standard has been subjected to debates and condemnation regarding the achievement or failure of its implementation and whether its costs balance the performance benefits for companies (Castello Dalmau, Gimenez and De Castro, 2016).

In 2010, a terrible incident took place in an offshore drilling operation in the Gulf of Mexico. The incident which involved the Deepwater Horizon (DWH) oil spill that took place on the 20th of April 2010, is identified as Macondo incident (Vinnem and Røed, 2020). The incident is recognized as the largest in the history of the petroleum industry according to Kato (2016). Additionally, this caused a fatality of 11 people, 17 injured, and 210 million tons of crude oil was lost and contaminated the environment the company in operation lost 6billons US dollars (Ryan et al., 2011). A comprehensive examination took place where many findings and recommendations were concluded, and the lack of a proper quality system was the main finding (Deepwater Horizon Study Group, 2011). Sharafedin (2016) states that in the past periods Iran experienced a fatal incident which took place within the Iranian oil and gas industry, whereby oil rigs amounting to $40 Million US dollars have collapsed into the sea caused by a fire which emerged due to a lack of appropriate quality management. A refinery complex in Iran Mobi Petrochemical experienced an incident caused by fire whereby it left 4 employees and the plant severely damaged (Sampaio, Saraiva, and Guimarães Rodrigues, 2011). In a case of a mishap alert from DrillSafe, the Southern African Drilling Industry Safety Forum, a security officer was 'press-ganged' into filling in as a drill rig operator in light of the fact that the standard individual from the drill team was ill; the watchman was subsequently harmed in a foot-cinch mishap. The harmed man had not experienced any preparation to set him up for the work being done, nor was he made mindful of the risks on the drill site or possessing all the necessary individual protective hardware at the hour of the mishap. The foot clasp that caused the mishap was likewise altered without endorsement of the maker (Colin Rice Exploration & Training, 2013).

There are two motivations as to what is the organization's quest to get a certification, it can be either internally or externally motivated. Safety has been regarded as paramount in the exploration drilling industry, this approach tends to overlook the implementation of Quality management standards and principles.

2.3 Overview of Quality Management in Drilling Exploration

To lead a successful organization, there should be systems that are functional, transparent and efficient. This system should be aimed at, once implemented, meeting the needs of prospective clients to maximize economic success. This kind of success can be achieved by implementing quality management systems continually improving their performance and addressing the needs and expectations of interested parties (ISO, 2015). Typically, the need for quality management would arise due to an organization lacking leadership, having short term focus, lacking customer focus, struggling to find the trade-off between cost and quality, lacking system thinking, and lastly having a 'Human Resources' mentality (Knowles, 2011). Hence, the principles of quality management, if applied correctly, can assist any kind of business including exploration drilling in the improvement of the organization's performance (Gutierrez-Gutierrez, Barrales-Molina, and Kaynak, 2018). The following seven principles as stated in Table 1 replace the eight management principles addressed previously in ISO900:

Table 1. Benefits of Applying Quality Management Principles

Principles	Benefits
1. Customer Focus	Exploration business mostly deals with tendering for contracts with eligible mines or customers, to retain these customers, the standards promote customer retention by influencing the business to know their customer need and requirements and exceeding them.
Principles	**Benefits**
2. Leadership	The standard acts on an advisory level for Top Management in the exploration business to be involved in sharing and communicating the business strategy and the organization's vision and mission.
3. Engagement of People	Most employees are not involved in training and development. One of the findings made by Colin Rice Exploration & Training (2013) is that an employee operated a drill rig without proper training and competency resulting in injury. Organization's engagement of its people can result in improved workers and improvement to its processes.
4. Process Approach	Implementing appropriate processes may lessen incidents which are encountered through drilling operations, Colin Rice Exploration & Training (2013) reported that an incident occurred on one of the South African drilling operations whereby the foot clamp that caused an injury to an employee was also modified without approval of the manufacturer. Having quality control checks and supplier audits frequently as required by ISO 9001 can assist an organization to eliminate such incidents.
5. Improvement	This principle can be applied through constantly reviewing existing processes and maturing them.
6. Evidence Thinking	Drilling operations may apply this process by analyzing the existing integrated management statistics, process, customer requirements and surveys and make rational decisions out of the information.
7. Relationship Management	This principle may be implemented by keeping an exceptional relationship management system with clients, customers, stakeholders, and interested parties through their daily operations of the business by applying the 7 principles accurately.

3. Research Methodology

The methodology followed is a systematic review of the articles which were published between 2008 - 2019. A gap analysis was then formulated to select articles related to the topic discussed. The criteria used to select these articles includes:

a) Articles which are published by authors on a global scale
b) Between the years 2008- 2018
c) Technical reports addressing the life cycle of Mineral Exploration drilling, articles influencing the implementation of Quality Management Systems, Risk Management and Safety Management in drilling explorations.
d) Articles by authors who have confidence in implementing QMS
e) Articles by authors who have a had less confidence in implementing QMS

The initial assessment resulted in 94 articles being selected to be used for this report. Further assessment led to 38 articles being evaluated and summarized to create a framework of this report as presented in Table 2 below.

Table 2. Articles Reviewed

Author & Year	Problem Investigated
Juran and Godfrey (1999)	Juran's Quality Handbook
Moon, Whateley and Evans (2006)	Overview to Mineral Exploration
Asia et al. (2007)	The effects of Oil explorations operations on metals and water.
Hasan, Ali and Lam (2007)	Benefits of ISO 9001 and Total Quality Management for Business Improvement
Akin and Karpuz (2008)	Diamond drilling bit parameters to achieve better drilling techniques

Lin (2008)	Finding Flexible Strategies in Engineering Systems Using Screening Models Applications to Offshore Petroleum Projects
Kaziliūnas (2010)	Success for Quality Management System Factors for Quality Management System: Certification Benefits
Kreuzer and Etheridge (2010)	Consequences for Valuing Mineral Exploration Properties
Bayode, Adewunmi and Odunwole (2011)	Study to investigate consequences oil exploration may pose of the coastal area of Ondo State
Cao et al. (2011)	Types and models of coal-deposit exploration in China
Author & Year	Problem Investigated
Sylvester, Rani and Shaikh (2011)	Examination among oil and gas organizations and temporary workers against cost, time, quality and degree for venture achievement in Miri, Sarawak, Malaysia
Abedi et al. (2012)	Advanced methods to be used for exploring copper
Abedi and Norouzi (2012)	Incorporation of several geophysical, geochemical geological data to investigate copper drilling exploration
Department of Mines and Petroleum (2012)	Code of Practice: Mineral investigation boring is a pragmatic manual for help those associated with mineral investigation to create and execute safe frameworks of work for penetrating activities, especially in remote zones
Jablonowski (2012)	Identification of leading safety indicators in onshore oil drilling
Priede (2012)	Motives for implementing Quality Management system
Setyadi and Anggayana (2013)	Database to Management information generated during exploration drilling
Sharf, Malanina and Kamynina (2014)	Highlights of the promoting methodology of oil and gas organizations in exploration boring
Ramphal (2015)	Summary of the new ISO 9001:2015 standard and challenges which might be experienced
Baqir and Akhtar (2016)	Authoritative Cost-adequacy in Petroleum Sector: An investigation on investigation and creation organizations working in Pakistan
Castello Dalmau, Gimenez and De Castro (2016)	ISO 9001 Characteristics Associated to Performance and implementation
Roy and Ghose (2016)	Review on the Implementation of Quality Management System in the organizations operations: North Bengal
Adam Górny, 2017	Decision and appraisal of modification estimates basic for process operation (about the prerequisites of ISO 9001:2015)
Elhuni and Ahmad (2017)	Evaluation of Total Quality Factors Deming Management Model in Oil Industry in Libya – An Empirical Study
Kafel and Simon (2017)	The Motives for not continuing with the ISO 9001 certification
Labella et al. (2017)	Adoption of Quality Management systems in Oil production industry
Maleki Sadabad and Pathirage (2017)	Comprehend the need of value culture in Project Management groups inside Iran's oil and gas industry
Purba, Dimwani and Adityatama (2018)	Basic Considerations in Minimizing the Uncertainty During Developing Geothermal Exploration Drilling Strategy in Indonesia
Harthy et al. (2018)	Variables Affecting the Quality Management System in OIL and GAS On-Shore Drilling Sector for IN-SOURCING Drill.
Roy and Ghose (2018)	The degree of patient fulfillment after execution of quality management system in human services associations and the advantages the association received
O'Donnell (2016)	Quality Management Systems applied in the Oil and Gas Industries.

4. Findings and Discussions

4.1 Advantages of Quality Management in Drilling

Between 2004 to 2010 there was an evident increase of ISO 9000 certification. For the first time in history in 2011, there were few certified companies worldwide compared to the previous years. Subsequently, the progression returns to a positive trend with a clear indication of stagnation on the certification of companies, as depicted in Figure 3. Except for all the benefit which can be accrued by implementing ISO certification, there are disadvantages related to the certification. Some of these disadvantages are increased costs, extra workload, lack of development of employees and limited time and focus on other organizational functions. The certification may prevent creative thinking as employees will be bound to follow organization standard operating procedures and rules.

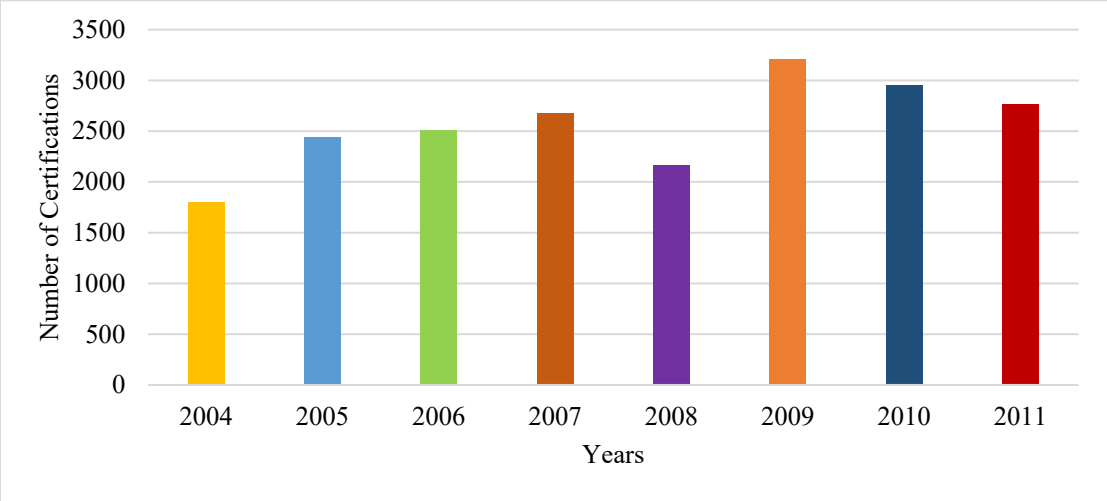

Figure 3. ISO Certification in Mining Industry 2004 - 2011 – Global Perspective

4.2 Advantages of Quality Management in Drilling

ISO 9001:2015 encourages and improves relationships with supplier and customers which improves confidence in stakeholders in respect to consistency, efficiency, and effectiveness, the objective of the standard is not only to meet customer requirements but to exceed expected results. (ISO 9001:2015). When a client requires quality verification of a product produced to specifications, on an ongoing basis, it is, therefore, recommended that rather than evaluating the final product, consideration must be taken with regards to the management systems implemented by the manufacturer. This assures the client that applicable and recognized standards were used (Heinz, 2008).

In a survey carried out by The British Assessment Bureau, it was found, from the returned answers, that it is a requirement to have an implemented QMS to successfully submit tenders. These are examples amongst other limitation experienced by smaller organizations which have no QMS being implemented. These limitations prohibit the smaller organizations from competing in the global market, another limitation exercised on the organization is the need for all employees involved are liable to have knowledge of the certification process and procedures applicable (The British Assessment Bureau (2011). ISO 9001 certified organizations outperform originations that are not certified with regards to product quality, operations, customer satisfaction, financial performance as noted by Psomas and Kafetzopoulos (2014).

Fatima (2014) states that to trade in the global market, companies in less developed areas are advised to have ISO 9001 certification and the author supports the finding that certified companies produce quality products that validate the strategic approach behind the certification. Fatima (2014) further argues by clarifying that organizations in underdeveloped nations need to have ISO 9001 accreditation to exchange on the worldwide market yet additionally proceeds to clarify that organizations with ensured quality administration frameworks were reliably delivering quality items, which expands the viewpoint that the key thinking behind affirmation was a more grounded contention.

4.3 Implications encountered in the market when implementing Quality Management

Other authors have criticized the ISO certification stating that it requires extra cost and fewer benefits are produced (Harthy Ali Malik AL et al). In 2013, a particular quality management framework known as American Petroleum Institute API Q2 was created which is viewed as the principal quality management framework explicitly designed for the oil and gas industry. Be that as it may, it was driven by offshore drilling exercises and a response to the Macondo episode, (API, 2013). Essentially, different ventures understood the need to have a quality framework that is explicit to the temperament of their activities. As it were, "fit for purpose" quality models.

Although a slight decline in company certifications issued between the years 2009 and 2011 has been observed as depicted earlier in Figure 3, there has been, however, a rapid increase in certification between 2012 – 2017 as depicted

in Figure 4. The dissatisfaction of other industries pulling out created pressure on ISO leading it to make changes to their model and adopt the risk-based approach through the release of the new version namely ISO9001:2015 in 2015.

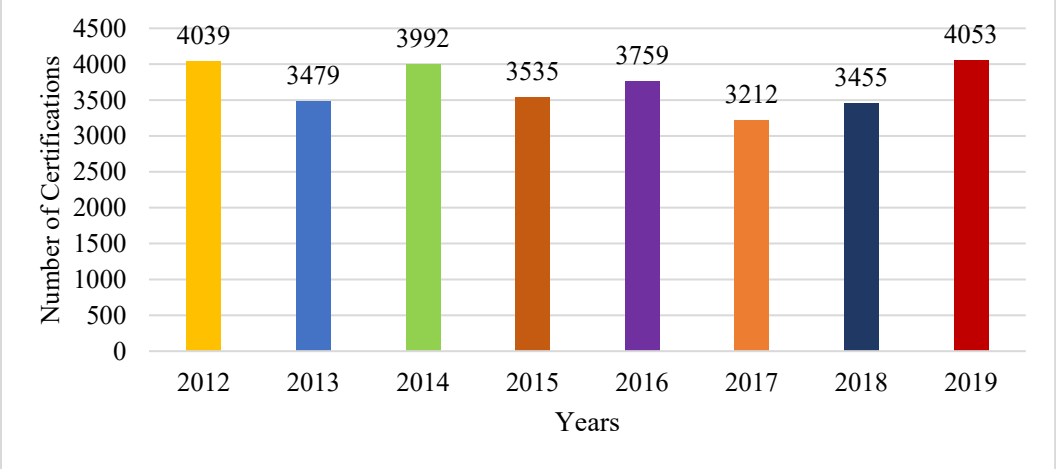

Figure 4. ISO Certification in Mining Industry 2012 – 2019 – Global Perspective

There is a substantial enhancement in organizations' financial standing following the implementation of QMS certification (Aba, Badar, and Hayden, 2016). QMS is usually implemented by organizations to improve their sustainability and longevity in the highly competitive market, and it is also utilized to enhance originations project performance. Quality does not only relate to the production process or the final products or services. The concept of quality is also used to improve processes and leadership styles within the organization (De Marco, 2018).

5. Conclusion and Recommendation

5.1 Conclusion

Based on the literature review, organizations have different reasons for implementing QMS, which yield different results after the implementation. The review also states that oil and gas drilling sectors moved away from the traditional ISO9001:2015. Consequently, it was deduced by different researchers that numerous companies from various areas are moving and leaving a conventional quality framework, for example, ISO: 9001, to increasingly explicit claimed quality frameworks where such organizations have demonstrated that such general framework is not productive nor proficient (Liu, 2009; Ostadi, Aghdasi and Baradaran Kazemzadeh, 2010; Miguel, Leal and Silva, 2011; Pai and Yeh, 2013; Alič, 2014; Kafel and Simon, 2017; Kim and Kang, 2017; Laskurain, Arana and Heras-Saizarbitoria, 2017; Wolniak, 2017; Chiarini and Vagnoni, 2018; Neves et al., 2018).

Exploration drilling is a very risky business and benefits numerous economies throughout the world positively. Based on this research information, Exploration Drilling Operations should implement QMS. The study has shown that there are fewer disadvantages in implementing the system, even though most authors who reviewed articles on Oil and Gas drilling have outlined the desertification experienced by the sector on the system. However, the growth of certification after 2011 proves that the implementation of this system is vital for any kind of drilling exploration operations.

As per the International Accreditation Forum (2015), the primary changes incorporate hazard-based thinking, less recommended prerequisites, less accentuation on records, improved appropriateness for administrations, expanded accentuation on hierarchical setting, expanded authority necessities and more noteworthy accentuation on accomplishing wanted results to improve consumer loyalty. the new ISO 9001 standard fortifies the necessities for suggested procedures, for example, mistake-proofing, management of change, and management of risk which were inferred in the past versions (Hampton, 2014).

5.2 Recommendations

The objective of international standards has been maturing and developing sufficiently (Lacković, Andrlić, and Lacković, 2009). QMS is an official system that includes creating a well-organized structure, activities, and processes compulsory to accomplish efficient quality management (Hellman and Liu, 2013). QMS is competent and very

significant in enhancing organizations' performance (Harthy et al., 2018). With the discussed findings on this report, the study recommends that exploration drilling operations should consider implementing QMS and to completely implement it as part of their integrated management system. The study discloses that QMS is vital for the continuous growth of any organization as highlighted by Roy and Ghose (2016).

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