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OPTIMIZATION AND BUSINESS IMPROVEMENT STUDIES IN UPSTREAM OIL AND GAS INDUSTRY: AN OVERVIEW

1.1 INTRODUCTION

1.1.1 Importance of Oil and Gas

Oil is inarguably the most important economic commodity and source of energy in today's world. It has shaped contemporary civilization and is intricately interwoven with our daily life touching every household. It fuels world economy, propels industrial growth, and impacts on nation's well-being. Oil accounts for one-third of world's energy need, while oil and gas together meet more than half of global energy demand. It will continue to dominate global energy mix in the foreseeable future. Oil is not only an economic commodity, but it has great strategic value too. The geopolitics of oil is well known, and the world has seen fierce disputes, even wars among nations for oil and gas. It influences world economy to such an extent that no country however mighty or humble can ignore it.

Life is unthinkable without oil and gas in the present-day world, which has pervaded not only our daily life but also deeply entrenched in the nation's economy encompassing all sectors including domestic, industrial, agricultural, transport, and other segments. For example, essential products, such as petrol, diesel, domestic gas, kerosene, naphtha, fuel oil, fuel gas, lubricants, wax, and so on, are derived from crude oil. It is a major component in many important products, such as fertilizers, organic chemicals, industrial chemicals, drugs, detergents, insecticides, cosmetics, and so on. It is also used in manufacturing household containers, furnitures, building materials, synthetic rubber, plastic goods, nylon clothes, CDs, DVDs, and many others. The transport sector is heavily dependent on it, and the world will come to a grinding halt without oil and gas. Ships, airplanes, trains, buses, cars, and so on, will stop plying; machineries, farm tractors, and factories will stop running; and industries using oil/gas as feedstock will close down [1].

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1.1.2 Early Use of Oil and Gas

There are many evidences and stories connected with the use of petroleum, especially oil and bitumen, in the ancient times. The "eternal fires of Baku" were the result of the ignition of oil and natural gas from seepage, the "tower of Babel" was constructed using bitumen as mortar, the basket in which baby Moses was hidden was believed to be made waterproof using bitumen, and Persians set alight the streets with sprinkling oil when Alexander the Great visited Persia. The multiple evidences suggest that in earlier days oil was used in Egypt, Persia, and Mesopotamia for heating, lighting, and paving roads. The records also suggest that North American Indians used petroleum as medicine, Mexican Indians valued bitumen as chewing gum, and Chinese were believed to be drilling wells using bamboo canes. Many famous explorers mentioned about it, for example, Sir Walter Raleigh wrote about it in his diary, Marco Polo noted that burning of mineral oil gave light and heat, and Christopher Columbus used bitumen to make his ship seaworthy [1, 2].

But it was not until A.D. 1859 that exploration for oil and gas started in earnest, when the first oil well was drilled by Edwin Drake in northwestern Pennsylvania, United States (some quarters claim it started in 1846 in Azerbaijan). Since then, a lot of advancement took place in the field of oil exploration and production (E&P), and there has been a phenomenal growth in petroleum industry, making it one of the most important sectors in the world influencing global economy and life of the people across the planet.

1.2 E&P ACTIVITIES AND PROCESSES

Hydrocarbon E&P is a complex process beginning with prognostication and involving a series of activities, namely, geological survey, magnetic survey, gravitational survey, seismic survey, laboratory studies, geochemical study, and exploratory drilling encompassing coring, casing, cementing, mud engineering, and drill stem test (DST) followed by well testing. Based on the well testing results, the well is declared as "dry" or "hydrocarbon bearing." If no oil and gas are found, the well is abandoned. In case of discovery, another set of activities follow, namely, drilling of appraisal well, delineating of field, and assessing commercial viability of reserves. Based on these, the decision of the development of the field is taken; however, the scale of development is dependent on the potential of the field. Accordingly, field development plans are made and development wells are drilled; production installations and surface facilities (group gathering station (GGS), gas collection station (GCS), central tank farm (CTF), effluent treatment plant (ETP), etc.) are created before commencing production. All these activities are highly capital-intensive, and the gestation period for the realization of investment is quite long.

1.2.1 High-Risk and High-Cost Activity

The upstream oil and gas industry is unique. In conventional industry, inputs and outputs are deterministic, that is, with a given input (investment), one is assured of the planned output (product or services). But in the upstream oil and gas industry, the input is deterministic, but the output (outcome of exploration activity) is stochastic. With the planned investment, one is not sure about its realization—it's more like a gamble associated with uncertainty and high risk. More often than not, investment in exploration may not yield fruitful result or any return. Even if oil and gas are discovered, its commercial viability is to be assessed before the next course of action is decided. It takes a long time to develop the field before production begins. All these make E&P activities high-risk and high-cost operations.

1.2.2 High Technology Activity

Oil and gas E&P activities are technology-intensive and require expertise of diverse fields. E&P activities are essentially the application of various streams of science and engineering, such as science (geology, geophysics, geochemistry, palynology, mathematics, and statistics); engineering (petroleum, chemical, reservoir, mechanical, electrical, civil, marine and ocean, electronics, instrumentation, telecommunication, and computer science); and many others.

With depletion of easy reserves, E&P activities are becoming highly technology-intensive, as the search for oil and gas is directed to geographically and geologically difficult locations, such as deepwater exploration, arctic region, snowbound hostile terrains, mountains, deep oceans, high-pressure and high-temperature horizon, and other challenging areas. Moreover, with a phenomenal rise in global demand for oil and gas, future oil/gas production will mostly come from more difficult reservoirs, such as deeper horizon, low API gravity, and high sulfur content. Furthermore, the production of oil from aging field using conventional technology is a challenging task. The conventional technology too needs continuous improvement to sustain oil production from matured fields. *All these necessitate continuous development and induction of state-of-the-art technology, which are costly and require experts to use it and make the best out of it*. E&P activities are associated with high technology that requires multidisciplinary approach and expertise to operate "state-of-the-art technology" and cope with increasing demand and difficulties in oil and gas E&P.

1.3 NEED FOR OPTIMIZATION IN UPSTREAM INDUSTRY

We have seen in the earlier paragraph that oil and gas E&P activities are becoming increasingly costly, risky, and technology-intensive as operations are moving from easy to difficult and challenging frontiers. In order to mitigate risks and share the cost of operations, even the major and super major oil companies are forming joint ventures and consortium for venturing in new frontiers. In view of inherent risks and uncertainty associated with the upstream business where inputs are deterministic but output is probabilistic, it is important that oil companies use their capital and resources judiciously. It is necessary to optimize strategies, resources, and cost and improve business performance in all spheres of E&P activity. These are the need for survival and sustaining business. The rule of the game is "money saved is money earned." All these require innovative ideas, change in mind-set, fresh outlook, and approaches to business.

1.3.1 Optimization Techniques

Optimization is an oft-repeated word used by all, whose meaning perhaps is not as clear as it seems to most of the people. It's a catchy word! People use it liberally, as it sounds impressive without knowing its nuances or relevance to the context. Most people consider it as a synonym of maximization/minimization, and the differences are indistinct even to professionals and management people.

Optimization in its simplest form means the best available value or most favorable result *under a given set of conditions or constraints. It is usually the* maximization or minimization *of objective function subject to a set of constraints*. Optimization is basically a mathematical technique, which is widely used in engineering, management science, economics, science, mathematics, and many other fields. Literature is replete with definition of optimization with varying degree of simplicity or complexity.

The genesis of "optimization technique" traces back to the work of Fermat and Lagrange for identifying optima with calculus-based formula. Newton and Gauss used iterative methods for moving toward an optimum solution. In modern days, George B. Dantzig developed an optimization technique called "linear programming" based on simplex algorithm. It was developed during World War II for scheduling warfare logistics and related problems for US military. Much of the work of G. B. Dantzig was based on the theory introduced by Leonid Kantorovich in 1939, but Dantzig made substantial improvement on it making it more powerful and versatile [3]. Based on the types of objective function and set of constraints, the optimization models/techniques are classified as linear programming, integer programming, geometric programming, goal programming, quadratic programming, nonlinear programming, fractional programming, dynamic programming, and so on. These are essentially the extension of either linear programming or particular case(s) of nonlinear programming.

Various optimization and business improvement techniques have been used in this book, such as benchmarking, technical and qualitative analysis to optimize productivity of drilling operation (Chapter 2); diagnostic approach and root cause analysis to optimize controllable rig time loss (Chapter 3); technical, qualitative, and economic analysis to optimize geology and geophysics (G&G) strategy for deepwater oil and gas exploration (Chapter 4); queuing theory to determine optimum number of offshore supply vessel (OSV) fleet size (Chapter 5); technical and statistical analysis for standardizing consumption of consumables in oil/gas wells and rigs (Chapter 6); critical path analysis using Program Evaluation and Review Technique/Critical Path Method (PERT/CPM) to optimize rig move/mobilization time and activity scheduling (Chapter 7); development of uniform standards for emergency alarm systems and indicators at offshore installations based on recognized international codes (Chapter 8); qualitative and quantitative analysis to optimize supply chain management (SCM) system (Chapter 9); best practice benchmark, work study, qualitative and quantitative analysis for manpower optimization, and strategic workforce planning (Chapter 10); enhancement of organizational efficiency through business process simplification (Chapter 11); and linear programming to optimize base oil price (Chapter 12).

1.4 IMPORTANCE OF CREATIVITY AND DATA USABILITY FOR BUSINESS PERFORMANCE IMPROVEMENT

E&P companies usually maintain a plethora of operational data and use these in good measure for preparation of reports, monitoring of activities, review, and decision making. Apart from these, the huge caches of data mostly remain in archive with limited usability, but this can turn to a treasure trove, if dealt with innovatively. What's needed are creative ideas, fresh outlook, and analytical abilities, which are often stifled in this fast-paced business world. Although there is no dearth of talent but work pressure, tight schedule for delivery, annual commitment, and so on, don't leave much room for creativity to flourish. A good idea or groundbreaking study need not necessarily be complex; in fact, most of them spring from simple ideas. A good idea or powerful study is easy to understand and easy to implement and brings in desired improvement. The characteristics of a good idea or innovative study are that it looks simple and is easily understood by most of the people, yet no one conceived or figured it out until it was presented. Like no one bothered till Sir Isaac Newton explained—"why apple falls on the ground." That's the hallmark of creativity!

1.5 OVERVIEW OF THE BOOK

As the title suggests, this book deals with optimization and business improvement studies in the backdrop of upstream oil and gas industry, but some of these studies, approaches, and techniques are also applicable to other industries. The book contains studies on optimization of strategies, resources, and cost; improvement in business performance and operational productivity; identification and removal of inefficiencies; standardization of consumption of materials; standardization of important safety measures; business process simplification, manpower optimization, improvement in human resource productivity, and so on. Various business processes, systems, and operational areas in E&P business were studied, inefficiencies were identified, and measures for improvement were suggested. The purpose of the book is not to delve deep into the operational technicalities but to emphasize on the approach for optimization and improve operational and functional performance using quantitative and qualitative tools. Therefore, technical discussions related to operational and functional areas have been kept at necessary level.

The book is divided into 12 chapters; besides the introductory chapter, it contains 11 real-life optimization and business improvement studies that are worth mentioning and emulating. Chapter 1 is the introductory part that explains the purpose and structure of the book. It portrays the overview and chapterwise contents of this volume covering a wide spectrum of activities from E&P operations to business process improvement and the like.

In order to contain the spiraling cost of drilling, especially at offshore, the E&P companies and drilling operators are continuously trying to improve the productivity of drilling operation, which is a necessity for survival in these days. Chapter 2 deals with optimization of productivity of drilling and dispels few long-held beliefs in the organization about poor performance of own rigs compared to the hired rigs. The study diagnoses areas of concern, identifies major factors affecting drilling performance, and categorizes these as *human factors*, *organizational factors*, and *technical factors*. All these factors and subfactors were analyzed, and remedial measures were suggested for optimizing the productivity of drilling operations with the potential of saving around USD 60.5 million per year for offshore Asset under study.

Drilling is a capital-intensive activity consuming a lion's share of the capital budget of an E&P company. Therefore, it is desirable to minimize nonproductive drilling time and improve rig time availability. Chapter 3 discusses optimization of controllable rig time loss using diagnostic approach. The study identifies causes of rig time loss, quantifies, and groups these under five categories, namely, waiting on material, waiting on decision, waiting on logging tool, equipment repair downtime, and other shutdown. The study reveals that controllable rig time loss accounts for 14.2% of available rig-days costing around USD 60.5 million per year in the Asset under study. Remedial measures to minimize these losses have been suggested, which would entail a saving of around USD 34.5 million per year in the Asset under study.

Deepwater exploration holds promising prospects for the future, as easy oil and gas reserves are depleting fast in this oil-hungry world. But deepwater exploration is costly, risky, and technologically challenging, which necessitates extreme economic prudence and strict monitoring of E&P operations. Ironically, some G&G activities escape attention because of inherent subjectivity and uncertainties involved in these operations. Chapter 4 aims to optimize G&G strategies for exploring oil and gas in deepwater and analyze some G&G decisions and their effect on well economics through the following: (i) optimization of G&G evaluation time in deepwater wells, (ii) techno-economic assessment of acquiring logging while drilling (LWD) in own deepwater rig, (iii) improvement of accuracy of geological predictions, (iv) effect on downhole complications due to variation in formation pressure (between actual and predicted pressure in a well), (v) containment of slippage in deepwater well completion, and (vi) influence of people's factors on the success and performance of deepwater exploration. The study provides valuable insights and offers suggestion in these areas, which would help in optimizing G&G strategy in deepwater exploration with the potential of saving around USD 50 million in less than a year.

OSV is the lifeline of offshore E&P operations. Waiting cost of offshore installations is extremely high, and it is undesirable that installations wait for materials that are supplied by OSVs. Therefore, adequate number of OSVs is required for uninterrupted operation, but OSVs are also costly items. It is necessary to trade-off between waiting time of installations and that of OSVs. Chapter 5 develops a queuing model to optimize OSV fleet size with the objective of minimizing waiting time of installations, which in turn would lead to optimizing waiting cost of installations and the total system cost. The study also determines various operating characteristics of the queuing model, which would help in decision making under dynamic conditions.

Chapter 6 deals with standardizing consumption of high-speed diesel (HSD), cement, and chemicals in oil/gas wells and rigs to prevent stockout situation, avoid excess inventory, monitor consumption, check wastages and aberrations, and help drawing future procurement plan. HSD consumption depends on various technical, geological, and physical factors. **Average HSD consumption** per meter drilling for similar category and capacity of rigs operating in similar geological formation and depth with similar rate of penetration was grouped for standardization. Accordingly, unit fuel consumption for different types and capacities of rigs in different regions/Assets/Basins were computed and standardized both at onshore and offshore. Suggestions have been offered for the improvement of HSD consumptions in drilling rigs, which can save up to USD 62.8 million per year. **Consumption of cement** depends on various technical and geological factors like casing policy, hole size and depth, cement rise, number of objects to be tested, activity and mud loss, downhole complications, and so on. Consumption of cement was standardized for different casing policy wells in different fields/regions taking into consideration the aforementioned factors. **Consumption of chemicals** in an oil/gas well depends on various technical and geological factors, such as well depth, formation pressure, lithology, and borehole instability, to mention a few. The unit consumption (kg/m) of chemicals in oil/gas wells varies widely with high standard deviation, not only in different fields but even within the same field. Therefore, consumption range and upper limit of consumption of chemicals have been determined for various groups of wells.

Rig move/mobilization is considered as unproductive rig time, which needs to be minimized to ensure more time for drilling and completion. Network analysis using PERT/CPM technique has been used in Chapter 7 to optimize rig move time and develop optimal activity schedule. The study identifies critical path and critical activities and focuses on timely completion of critical tasks to avoid delay in rig move/mobilization. The study suggests a set of recommendations for optimizing rig move time and activity schedule, which has the potential of saving 500 rig-days amounting to USD 30 million per year in the E&P company under study.

Chapter 8 focuses on developing uniform standards for emergency alarm systems and code of signals for offshore installations of an E&P company, which are found to vary widely. This creates confusion and possesses safety threat to offshore-bound personnel, especially those who frequent different installations. The study classifies different emergency situations, and provides useful guidance for developing code of signals for emergency alarm system and indicators based on recognized international codes. It suggests uniform adoption of standards across various offshore installations of the organization.

Chapter 9 deals with optimization of SCM system and highlights importance of SCM system for smooth functioning of E&P operations. It identifies opportunities for improvement by assessing maturity of key supply chain functions and benchmarking these with comparable industry standard. The study aims to improve procurement cycle time by streamlining material planning, tendering, and order execution processes along with other measures. It also suggests improvement in inventory management and warehouse functions. Furthermore, the study emphasizes the need for SCM support services, namely, demand forecasting, strategic procurement, and vendor relationship management, which are currently unorganized or nonexistent in the organization under study. The recommendations made in this study can improve SCM system in the organization and have the potential of saving USD 244 million per annum.

Chapter 10 discusses manpower optimization and strategic workforce planning of an E&P company emphasizing on multiskilling, multidisciplinary approach to improve employee utilization and productivity and enrich the quality of human resources. It rationalizes the large pool of disciplines/subdisciplines and impresses on modification of the organization's manning norms aligning with the best practice benchmark. It studies the current manpower planning process in the organization, finds out shortcomings that are not conducive to good practices, and suggests measures to overcome these. A real-life case study has been presented illustrating the process of manpower optimization that includes demand forecasting, supply (availability) prediction, and balancing demand–supply gap. The study reveals that there is enormous scope for savings on account of manpower optimization in the organization, approximately USD 290 million.

Chapter 11 illustrates some real-life examples of business process simplification, which is a powerful tool to improve system efficiency, especially in large enterprises where processes are deeply embedded in organizational structure and culture and seem inseparable. The study highlights the efficacy of business process simplification in improving customer satisfaction and service quality, reduction of processing time, elimination of nonvalue adding tasks, and duplication of efforts, freeing up scarce resources and creating awareness in an enterprise.

Oil pricing is a complex and sensitive issue, which is not dependent on economic criteria alone—a set of environmental factors like social, political, technical, and geopolitical issues strongly influence it. Chapter 12 develops a quantitative model to optimize base oil price for a country using linear programming, taking into account the cost and share of domestic oil production and that of oil import and other factors. It aims to maximize profitability and drive oil production by reinvesting into E&P activities. It is an illustrative model that develops a framework to study the effect of various parameters on base oil price and aid decision making under dynamic circumstances.

All these are real-life examples of optimization and business improvement studies, which are based on simple concept, notwithstanding inherent uncertainties involved in E&P business. A wide range of topics are covered in the book containing powerful drivers to capitalize opportunity cost and shore up business performance. These studies are easy to emulate and have the potential of saving billions of dollars, besides improving organizational efficiency.

REVIEW EXERCISES

1.1 Describe the importance of oil and gas in today's world.

1.2 What are the sequence and process of E&P activities?

1.3 Is there any need for optimization in upstream industry? Explain.

1.4 Define optimization. Is it different from maximization/minimization? Explain.

1.5 What are the various optimization techniques you are aware of? Mention their applicability.

REFERENCES

[1] Chowdhury, S., Striking Oil, Science Reporter, Volume 31, Number 5, May 1994, pp. 9–12, 35.

[2] Mee, A., Children's Encyclopedia, Vols. 3 and 4, Everybody's Publications Ltd., The Educational Book Company, London, 1963.

Useful Link

[3] Wikipedia, Mathematical Optimization, available at: http://en.wikipedia.org/wiki/Mathematical_optimization (accessed on February 27, 2016).

FURTHER READING

Campbell, J.M., Campbell Petroleum Series, Analysis and Management of Petroleum Investments: Risk, Taxes and Time, 2nd edition, PennWell Publishers, Tulsa, OK, 1991.

Campbell, J.M., Campbell, C.W., Campbell, R.A., Friedman, G. Campbell Petroleum Series, Mineral Property Economics, Vols. 2 and 3, The Campbells, Tulsa, OK, 1980.

Hobson, G.D. and Tiratsoo, E.N., Introduction to Petroleum Geology, Gulf Publishing Company, Houston, TX, 1981.

Mohan, C. and Deep, K., Optimization Techniques, New Age Science, Kent, 2009.

North, F.K., Petroleum Geology, Allen and Muir, Inc., Winchester, MA, 1985.