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Application of just-in-time manufacturing techniques in radioactive source in well logging industry

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A B S T R A C T

Nuclear logging is one of major areas of logging development. This paper presents an empirical investigation to bring the drilling and completion of wells from an ill-defined art to a refined science by using radioactive source to "look and measure" such as formation type, formation dip, porosity, fluid type and numerous other important factors. The initial nuclear logging tools records the radiation emitted by formation as they were crossed by boreholes. Gamma radiation is used in well logging as it is powerful enough to penetrate the formation and steel casing. The radioactive source is reusable so that after engineer finished the job the radioactive source is sent back to bunker. In this case inventory level of radioactive source is relatively high compared with monthly movement and the company must spend large amount of cost just for inventory. After calculating and averaging the monthly movement in 2014 and 2015, we detected a big possibility to cut the inventory level to reduce the inventory cost.

1. Introduction

From early surface mining experiment to modern nuclear physics, formation logging has been the backbone of oil and gas development, letting geologist, geophysicists and engineer to see more and more of subsurface. The advent of well logging in the 1920s, and its subsequent development into a sophisticated technology, revolutionized the exploration and production industry. The ability to "look and measure" such as formation type, formation dip, porosity, fluid type and numerous other important factors brought the drilling and completion of wells from an ill-defined art to a refined science. There have been three major areas of logging development: electric, sonic/acoustic and nuclear. To understand the development of each is to understand the industry's technical progress. Meanwhile, logging using radiation of nuclear origin got its start in 1940. The initial nuclear logging tools recorded the radiation emitted by formation as they were crossed by boreholes. Gamma radiation is used in well logging as it is powerful enough to penetrate the formation and steel casing (Pike, 2002). Every company in industry must be able to optimize the market demand in order to avoid over or lack of inventory. This is important because large amount money is needed to keep the inventory level. Inventories also is one part that absorbs the greatest investment. The investment value of the company in the form of

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goods inventory amount varies between 25% -35% of the value of all assets (Indrajit & Djokopranoto, 2002). The reasons to keep low inventory levels are: (i) Obsolescence: due to advances in technology and changes in product design, parts procured for future use may become obsolete, leading to a substantial loss. Also, in food-related industries, outdated food products must be thrown away, leading to a waste of resources, (ii) Capital investment: inventory ties up a substantial capital of the company and may not allow the company to be agile in response to market fluctuations, (iii) Space usage: inventory occupies precious usable space that may be essential for other purposes. Also, the space is usually costly to maintain. (iv) Complicated inventory control systems: a higher number of inventory items complicates the control and monitoring, such as identifying where items are and how many items exist (Malakooti, 2013). A successful just in times (JIT) implementation may provide significant benefits for the operation of the whole company. There have now been a sufficient numbers of successful JIT implementations which reduces inventory levels, probably by about 50 per cent (Chaudhari & Patel, 2015).

2. Literature review

JIT is a Japanese management philosophy applied significantly in many industries for more than four decades. The idea of JIT was first implemented within the Toyota to meet consumer's demands with minimum delays (Schonberger, 1986). It received substantial support during the 1973 oil embargo and was later implemented by several organizations. JIT has chained into a management philosophy enhancing significant amount of knowledge and including a comprehensive set of manufacturing principles and techniques. JIT manufacturing enables the organization to strengthen their competitiveness in the marketplace the organization's competitiveness in the marketplace by reducing wastes and improving product quality and efficiency of production. According to Zipkin (1991) a big portion of confusion still exists about the subject of JIT and there are different approaches of JIT implementation in the west, which could influence the contribution of the JIT implementation. There are strong cultural perspectives related to the emergence of JIT in Japan. The development of JIT within the Toyota production firms did not happen alone of the cultural influences and the Japanese work ethic was one of them, which was emerged shortly after World War II and was observed as part of the Japanese economic success and it is a motivating factor for the development of the best management methods (Javadian Kootanaee et al., 2013).

The concept of the JIT is separated from conventional productions systems based on push vs. pull systems of production. The earlier system of production pushes materials to the next part of the production irrespective of whether time and resources are required at the next level of production generating significant amount of inventories at each level of the production flow. The conventional manufacturing firms adopting push system face with huge amount of inventory and work in progress. The pull system of production is based on the idea that the materials are pulled by next level of the production only when is necessary by the next stage of production. This significantly reduces the inventory kept as it does not require to hold any work in progress. The ideal of JIT is based on the concept of pull production which removes the total inventory. This article discusses in depth the implementation of JIT manufacturing. The objectives are twofold. The first objective is to get insight about the overall JIT concept and the factors necessary for its implementation; the concepts given here represent the ideal principles and methods of implementation (Javadian Kootanaee et al., 2013). Inventory contains a detailed list of movable items in the form of raw materials, in-process or finished products required in the producer of goods or to keep the machinery and equipment under good conditions and it is an important part of any firm. Inventory absorbs fluctuations in demand or supply of goods which disturb the schedule of the enterprise. It also helps in holding manufacturing activities uninterrupted, which leads to better utilization of men and machines. Inventory maintains some expenses, as it needs valuable space, capital and other overheads to keep, which constitutes a substantial part of the total cost of a product. The invested cash gets blocked as long as the inventories are not getting consumed. Extensive inventory includes more blockage of money, which can be implemented elsewhere for other useful purposes.

Hence inventory requires to be managed effectively and needs careful consideration and therefore offers a strategic advantage. Excellent in-house inventory management may influence positively on the overall production costs (Singh & Singh, 2013). Inventory control is the scientific method of determining the proper amount of inventory to reach the manufacturing needs on time and to reduce the overall expense of production. The aim of inventory control is to make sure that a proper reserve of goods is available based on the manufacturing plan according to the sales requirement. One of the key functions of inventory control is to minimize the amount of inventory held by the company in terms of materials, work-in-process and finished goods (Tersine, 1994).

JIT philosophy is based on simple idea that wherever possible no activity should happen in a system until there is a necessity for it. It needs the parts to make available at the time of their necessities and not before. It looks for production of the required items at the required time, and in the required quantities. JIT inventory management builds a balance between optimum inventory quantity and its holding cost. Inventory made available in right quantity at right price and in right time is the primary objective of JIT. JIT is a technique in which stock held by the firm is considered in terms of hours of production rather than in days or months (Karmarkar, 1989; Ward, 1994). It removes waste through simplification of manufacturing processes (Harmon & Peterson, 1990; Schonberger, 1986), removes excess inventory to reduce related production expense and concentrates on the implementation of small lot size to reach quick customer needs. Inventory managed on JIT basis eliminates different kinds of uncertainties in a production system. It assures timely delivery of required products to the customers and thus helping the firm reach its brand status. Inventory management is closely associated with supply chain management. A supply chain is described as a network of facilities and distribution options between start and end points, which include the functions of procurement of raw materials, transformation of these goods into finished products, and the distribution of the finished products to the end users (Kaihara, 2003). Supply chain management (SCM) effectively integrates the information and materials flow within the supply chain network beginning from product design to delivery (Verwijmeren, 2004). Combining related activities of a production system helps us reach smooth flow of materials and cut the level of in-process inventory significantly. The right product becomes available at right time to the customer, which is mainly due to reduced cycle times because of simplified and accelerated operations which is in line with the working with JIT (Oz Effy, 1999). The productivity can be increased substantially with the improvement in the supply chain network. At the same time, SCM helps in cutting business expenses and increases profits through reduced level of inventory. Information system in inventory management information system is a system of sharing information, and consists of computer hardware, communication technology and software designed to handle information related to business functions (Flowers, 1996). An efficient information management system integrated with appropriate manufacturing planning will substantially reduce piling of stocks and lead time and ensure timely delivery of quality products to the customer, confirming the JIT system. SCM information system is prepared to give necessary information to help the strategy, operations, management analysis, and decision-making functions. It also gives high quality, relevant and on time information flow that efficiently supports decision-making for inventory replenishment, capacity activation, and for enhancing material flows at all levels within the supply chain (Soroor et al., 2009). The use of Internet, Intranet, Extranet and EDI helps to have competitive advantage for the organization. It has made sharing of information easier and faster and organizations using Internet have grown faster in a very short amount of time. Since suppliers are located in different locations, it is important to collect their activities both inside and outside of the firms. This needs an integrated information system for sharing data on different value-adding activities along the supply chain. Information technology is like a nerve system for SCM. Hence development and implementation of effective information system for SCM is of utmost importance. A supply chain network may fail in the absence of effective information system. The “Bullwhip Effect” is an essential effect caused due to inefficient supply chain network. It shows the propagation and amplification of orders from one reordering system to another upstream in a supply chain. This effect causes uncertainty in the SCM leading to increase on-costs as organizations in the supply pipeline mitigate against the

potential risks in customer service levels by, say, increasing available capacity or increasing stock holding (Metters, 1997). The challenge for today's business is to produce quality products or services offered. Quality is the demand of the market and no manufacturer can afford to overlook it without loss of business. Customer's awareness about quality has increased substantially. Quality plays the key role in inventory management and accelerates JIT implementation. Quality ensures defect-free products and reduces work-in-process (WIP) inventory significantly. It reduces inspection costs, which has a direct effect on production cost. It reduces lead time and ensures speedy delivery of products to a customer. A customer is more easily attracted towards quality products because of their ability to satisfy him to the maximum level (Singh, 2006).

3. Research methodology

The present study uses JIT system which focuses to minimize the level of inventory. The inventory is the number of radioactive source and its component used for well logging services. First, we classify all the radioactive sources. Based on the monthly movement, there is a possibility to cut the inventory to a lower level for saving cost. Next, we calculate the cost to minimize the inventory of radioactive source used for well logging.

4. Process improvement

Table 1 shows the monthly movement for the radioactive source and each component.

Table 1
Monthly Movement (Unit) in 2014 and 2015

Component	Average Monthly Movement (Unit)
Neutron Source	5
Gamma Source	5
Stabilization Source	12
Pulse Neutron Generator	4
Gamma Ray Blanket	5

The radioactive source and its component prices can be seen in Table 2 as follows,

Table 2
Cost for Saving Radioactive Source

Component	Price Unit (USD)
Neutron Source	35,000
Gamma Source	34,000
Stabilization Source	600
Pulse Neutron Generator	25,000
Gamma Ray Blanket	5,000

To keep the radioactive source, Company also must have **usage permit** for each radioactive source which is the permit from the government, which helps us use the radioactive source. This permit also needs if the company wants to keep the radioactive inside the bunker. Table 3 and Table 4 show the details for annual inventory cost.

Table 3
Annual Inventory Cost

Component	Amount (Unit)	Price (Unit)	Total Cost (USD)
Neutron Source	21	35,000	735,000
Gamma Source	12	34,000	408,000
Stabilization Source	60	600	36,000
Pulse Neutron Generator	13	20,000	260,000
Gamma Ray Blanket	20	5,000	100,000
Grand Total			1,539,000

Table 4
Annually Usage Permit Cost

Component	Amount (Unit)	Permit Cost (USD)	Total Permit Cost (USD)
Neutron Source	21	8	168
Gamma Source	12	8	96
Stabilization Source	60	8	480
Pulse Neutron Generator	13	8	104
Gamma Ray Blanket	20	8	160
Grand Total			1,008

Based on the results of Table 3 and 4. The total cost that must be provided by company for inventory is USD 1,539,000 + USD 1,008 = **USD 1,540,008**.

Base on Table 1, monthly movement in 2014 and 2015 and calculate the necessary inventory cost and the results are shown in Table 5 and Table 6.

Table 5
Monthly Needs for Radioactive Source and Components

Component	Amount (Unit)	Price (Unit)	Total Cost (USD)
Neutron Source	5	35,000	175,000
Gamma Source	5	34,000	170,000
Stabilization Source	12	600	7,200
Pulse Neutron Generator	4	25,000	100,000
Gamma Ray Blanket	5	5,000	25,000
Total			477,200

Table 6
Annually Usage Permit Cost Based on Monthly Movement

Component	Amount (Unit)	Permit Cost (USD)	Total Permit Cost (USD)
Neutron Source	5	8	40
Gamma Source	5	8	40
Stabilization Source	12	8	96
Pulse Neutron Generator	4	8	32
Gamma Ray Blanket	5	8	40
Grand Total			248

Based on the results of Table 5 and Table 6. The total cost that must be provided by company for inventory is USD 477,200 + USD 248 = **USD 477,448**. Based on the results, company spends large cost for inventory but after cutting the inventory into the lowest level based on monthly movement in 2014 and 2015, company can also save significant amount of cost for inventory. Detail is shown on Table 7.

Table 7
Saving Inventory Cost After Cut the Inventory to The Lowest Level

Total Inventory Cost Before Cut the Inventory Level (USD)	Total Inventory After Cut the Inventory Level Based on Monthly Movement (USD)	Total Saving Inventory Cost (USD)
1,540,008	477,448	1,062,560

5. Conclusion

This paper has presented an empirical investigation to reduce inventory level based on monthly movement. As a result, the company can save the inventory cost, significantly. Here we have focused only

on the monthly movement and reported that there was a possibility for company to cut the inventory level of radioactive source.

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