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Assessing Safety Prognostic Technology for Complex Petroleum Engineering Projects

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***Abstract*—** Technological advancements have a broad scope in terms of experimental, analytical, field cases and numerical studies in complex petroleum engineering projects. These can be pertinent to transportation system and gathering and safety in oil and gas production. The current research was aimed at examining the challenges pertinent to safety prognostic technology as well as various ways in which it can be implemented for resolving issues in complex petroleum engineering projects. For the conduct of this research, qualitative methodology was used and primary data was assessed to present critical evaluation of the stated aim. The interviews were conducted from 10 petroleum engineers working in different public and private companies in Pakistan. The snowball technique followed by thematic analysis data analysis technique was applied for the generation of primary findings. The results of the research examined that safety prognostic technologies are significant in terms of enhancing safety, reliability and reducing the possible errors in maintenance. It has further examined that in complex engineering systems, there are multiple propagation paths to different consequences some of which might differ with respect to the most single faults.

***Keywords*—** Complex Petroleum Engineering Projects, Safety Prognostic Technology, Diagnostic Models.

I. Introduction

In complex petroleum engineering projects, a special focus has been placed on the advanced technologies for production, drilling and reservoir engineering (Zhang & Hu, 2013); (Tewari, Dandekar, & Ortiz, 2018). This has created a significant impact on today's petroleum sector from the exploitation to advanced non-conventional and non-conventional technologies from atypical hydrocarbon resources in the diverse applications of petroleum engineering (Ershaghi & Paul, 2017). According to (Tiddens, Braaksma, & Tinga, 2015), in most of the complex engineering projects, products and processes such as transportation system and gathering, compressors and pumps in the long-distance pipelines, close relationship to oil and gas production, and various chemical equipment, and technological advances are increasing at a rapid pace.

Moreover, as stated by (Zhang & Hu, 2013), one of the effective technological integration in the field of engineering has been identified named as safety prognostic technology which is useful for resolving the challenges pertinent to complex projects. This is considered suitable for posing substantial challenges in ensuring proper control, design, management and safety for continuous operations. In general, safety prognostic techniques are known for aiding the owner of the project in optimal decision making. Besides, this can also be utilised for the reduction of safety and business risks which can often be faced by the failure of critical systems to cater cycle costs (Tiddens, Braaksma, & Tinga, 2015).

In the research by (Tiddens, Braaksma, & Tinga, 2015), it has been analysed that progresses in the technologies of prognostic maintenance offer opportunities to aid the asset owner for life cycle decision making and optimal maintenance such as lifetime extension or replacement of physical assets. The research further elucidated that the literature related to specific technique on the usage and adoption of safety prognostic technology is limited as very few companies have integrated these for maintenance decision making. The results of this research presented that a range of organisational arrangements, maintenance technologies, products, industry and organisational arrangements are dealt with safety prognostic technologies. These are significant in terms of enhancing safety, reliability and reducing the possible errors in maintenance. Similarly, (Vogl, Weiss, & Helu, 2019) in their research presented that, recent progress by safety prognostic technologies has been observed to be promising in the engineering application of safety and risk assessment. In the complex projects of engineering, these technologies are expedient for inherently safer design, better quality of product, reliable process operations.

and abnormal events management (Zhang & Hu, 2013). However, as explained by (von Plate & M., 2016), prognostic and diagnostic components would be impossible without collection of data from sources such as programmable logic controllers (PLCs) and sensors. These are effective in complex petroleum projects related to lubrication and oil analysis, thermography, laser alignment, etc. For the enhanced safety provided by automobile, General Motors (GM) are serving their customers with a data-driven prognostics and diagnostics. Additionally, in the study by (Epelle & Gerogiorgis, 2020), the researcher depicted the analysis regarding the rise in prognostics analytics in the field of petroleum engineering. It has examined that there are a plethora of sensors, data collectors and transmissions devices that deal with the challenges of malfunction in complex projects. The use of safety prognostic technology is suitable for forecasting the safety issues via predictive diagnostics and monitoring such that forecasts provide assistance in the major challenges that are faced in petroleum projects. Consequently, the process data and condition of a cracked gas compressor is utilised by an application of prognostics to generate future malfunction risk profiles as well as useful life distributions.

As analysed in the study by (Zhang & Hu, 2013), safety prognostic technology is required to predict and model the emergent behaviour in complex engineering systems. It is also pertinent to the examination of future effects of various hazards which can be caused by an initial abnormal event. It is useful in the sense of providing an early warning that offers adequate actions or methods to control adverse incidents by the minimum possible losses. The same study further highlighted that safety prognostic technology includes two different aspects i.e. prognostic control and prognostic analysis. Moreover, results of the research identified that the reaction of prognostic analysis with respect to management activities such as prevention and control, correction and degrading trend which has been initially caused by some basic abnormal events is highly effective (Zhang & Hu, 2013).

The safety prognostic techniques are crucial for dealing with the accident consequences and causes of the complex engineering projects. In addition, the rationale of these safety prognostic techniques is that they are not only limited to the subjective cognitive ability but also assess the objective complexity of accidents. This research has elucidated the importance of safety prognostic technology which has recently integrated for the effective monitoring of petroleum engineering systems. However, there is still a gap observed in terms of assessing the various aspects such as complex petroleum engineering systems and failure propagation behaviour as well as challenges pertinent to safety prognostic technology. Therefore, the current study was conducted with an aim to cater the existing problem by examining the various challenges in complex engineering projects and how in different ways safety prognostic technology can resolve these challenges potentially in the field of petroleum engineering.

II. METHODOLOGY

There are two types of research methodologies that are utilised for the conduct of any study based on the nature of the study. Research methodology is adopted for data collection and analysis classified as quantitative and qualitative research design (Hameed, 2020). According to (Basias, & Pollalis, 2018), dealing with the statistics and numbers in any research is attempted by the adoption of quantitative method. On the contrary, qualitative methods are utilised for the interpretation of data in textual format which is pertinent to exploration of human ideas and experiences. In the current study, qualitative methodology was used to examine the ways in which safety prognostic technology can be utilised for complex petroleum projects. In addition, qualitative method will be beneficial for carrying out analysis of data for the identification of hidden patterns and presenting and in-depth assessment suitable for the study by analysing the multiple perspectives.

A. *Data Collection Method*

Moreover, methods of data collection are categorised as primary and secondary. As stated by (Beer & Faulkner , 2014), primary data is collected by the collection of first-hand data such as interviews or focus group discussion. On the contrary, secondary data is the information that has already been collected by other researchers such as newspaper articles, company records, and journal articles. This research was carried out by the collection of primary data by conducting interviews from 10 petroleum engineers working in different field having association with the public and private companies. The participants were accessed by means of snowball sampling technique.

B. *Data Analysis*

A research analysis tool which is suitable for the assessment of primary data is termed as thematic analysis that assists in the quantification and analysis of certain themes and concepts (Erlingsson & Brysiewicz, 2017). As mentioned by (Neuendorf & Kumar, 2015) , it allows the researcher to examine hidden patterns in a systematic and reliable manner by making valid inferences, interpreting and coding documents. Furthermore, the use of thematic analysis was appropriate for this research as it allowed the examination of different valuable insights regarding safety prognostic technology and their uses for dealing with the issues in complex petroleum engineering projects.

III. ANALYSIS

A. *Safety Prognostic and Diagnostic Models*

The field of petroleum engineering from the perspective of processing and safety is both complex and dynamic. This is because petroleum industries often produce a multitude of products from the extracted crude oil, and hence require various equipment, possessing a multitude of causal relations among the process variables and the components (Sanni , 2018). Furthermore, literature analysis indicates that with the introduction of external variables such as environmental sustainability issues, and also due to the requirement of improved quality of fuels, the petroleum industries have optimised their processes in order to achieve better efficiency (Hasheminasab, Gholipour, Kharrazi, & Streimikiene, 2018). It is also to be noted that such optimisations also incorporate the element of cost-effectiveness, which is often accomplished through design changes of components (Bigliani, 2013). However, changing equipment design is accompanied by changes in their operational and management practices. Therefore, their safety measures also need to update consistently (Knegtering & Pasman, 2009). In order to manage the ever-growing system, automated, intelligent, high speed, and non-linear relationships are established among the process variables and their equipment (Yagiz, Gokceoglu, Sezer, & Iplikci, 2009). This necessitates early detection of errors and failures to limit the damage. Furthermore, safety prognosis requires step-wise systematic processes built-in to the system, so that in times of emergency, the system could self-regulate before human intervention is done (Patel, Prajapati, Mahida, & Shah, 2020).

The decision-makers of modern manufacturing facilities are shifting towards using diagnostic and prognostic safety technologies to cement their service-led competitive strategies. Therefore, from the equipment point of view, the safety market is shifting from “sale of product” to “sale of use” (Grubic, Redding, Baines, & Julien, 2011). On inquiry regarding decision support system in refineries, one of the interview participants responded:

“Decision support systems are not the solution themselves. They are only mediator between the computer and the human aspect of petroleum industry. Therefore, decision support systems have to be developed in line with specifics of the refinery”.

Since safety prognostics help in minimising the cost of maintenance by controlling the fault isolation and detection times. Therefore, companies are employing custom-based systems to detect equipment failure. The Equipment Health Management (EHM) system, as adopted by Rolls-Royce, is one such example (Rolls-Royce, 2009). However, survey data in the context of United Kingdom shows that only a small proportion of manufacturers are engaged in adoption of safety diagnostic technologies (Grubic, Redding, Baines, & Julien, 2011) . The findings could be further aggravated for petroleum refineries, since petroleum refineries produce a significantly large variation of products compared to manufacturing firms. Upon investigation of equipment health in petroleum refineries, one participant answered:

“The concept of proactive maintenance and servicing is not new. However, refineries differ in their financial and technical capability to comply with standardised maintenance practices. I think if practices are to be complied with diligently, significant amount of issues could be resolved without radical changes in the system”.

Since protection, safety, and post- error prognostic is crucial for modern equipment to save costs, therefore, a technique which could monitor and device prognosis of the entire industrial system is needed, which includes digital systems, structures, and components (Kordestani, Saif, Orchard, Razavi-Far, & Khorasni, 2019).

For this purpose, “Prognostic Health Monitoring (PHM)” as propounded by (Pham, Agarwal, Lybeck, & Tawfik, , 2012) includes monitoring of structural, thermal, and chemical loading throughout the life span of the integrated equipment, as shown in Fig.1.

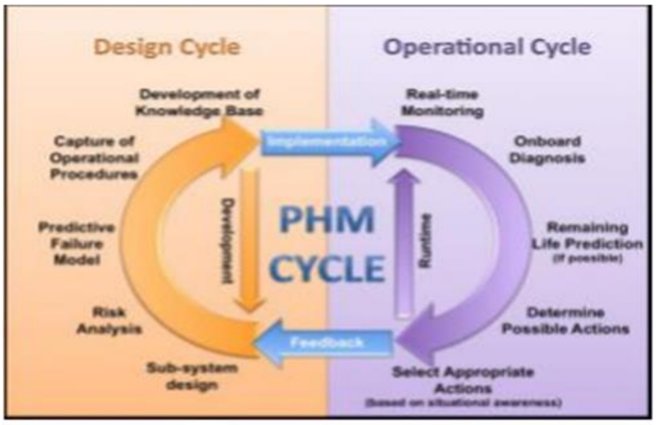

Figure 1. Cycle of PHM
Source: (Stecki, Cross, Stecki , & Lucas, 2012)

Although, installation of PHM in petroleum refineries would help in reducing operations and maintenance cost, and reduce plant outage time, however, it is also shown from literature that implementation poses an economic challenge from the perspective of nuclear industry (Pham, Agarwal, Lybeck, & Tawfik, , 2012). In order to minimise costs, selection of components to be monitored is important. Since equipment are classified into safety-related and non-safety related equipment, therefore, their integration within the PHM requires planning of prioritization (Moir, Niculita, & Milligan, 2018). Therefore, petroleum refineries undertaking PHM need to develop concomitant plan of operations, before adoption of PHM decision support system.

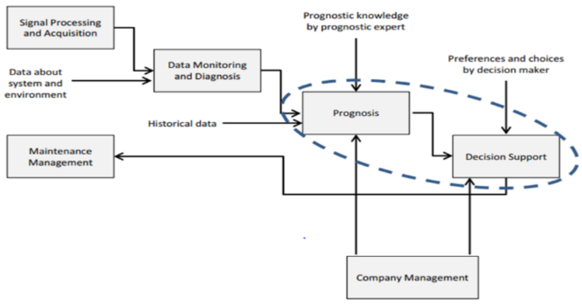

Figure 2. Planning and Equipment Selection for Integrated Decision Support

Planning and prioritisation could be accomplished through diagnostic models. Flow diagnostics, in this respect, are computational tools that are derived from controlled numerical flow experiments which obtain quantitative information regarding the flow behaviour of a reservoir model. In contrast to output from traditional reservoir simulators, flow-diagnostic measures can be obtained within seconds (Møyner, Krogstad , & Lie, 2015). This method could be utilised to evaluate the rank (the priority), and compared strategies of prognosis. In upstream oil extraction processes, the fault diagnosis comprises of monitoring of oil wells. For this, an automatic fault diagnostic system is equipped in the pressure cavity pump by (Horowitz, Faundez, Maestri, & Cassanello, 2014). The local model implemented by the system compares the pump variables at the time of fault with the previously generated library of faults signatures. In contrast, prognostic models, also known as RUL models (due to prediction of Remaining Useful Life) are intended to predict the time beyond which an equipment will no longer function efficiently. RUL models depend upon prior data acquisition which could be enhanced through aforementioned diagnostic methods (Horowitz, Faundez, Maestri, & Cassanello, 2014). Further, RULs are integrated with the decision support systems, to form the overarching Condition-Based Maintenance (CBM), as shown in Fig.1

Field engineer participants were inquired about their planning and equipment selection procedure. One interviewer responded:

"Planning and selection of equipment is done through our internal planning schedules. Usually there are no hard and fast guidelines for equipment selection. Thus, selection is done on the basis of qualitative assessment of engineers and their experience".

From the above response, it is clear that refineries adopt a subjective approach towards equipment selection. In petroleum industries, the CBM would include data on individual equipment such as the rotations per minute (RPM) of the drill, pressure differentials of pumps, temperatures and pressures within the process columns etc. (Bousdekis, , Magoutas , Apostolou, & Men, 2018). Because variety of equipment and processes involved is high, therefore, efficacious safety prognostic in petroleum industry requires techniques that could also monitor the evolution of equipment over time. (Hu, Zhang, Ma, & Liang, 2010) propose an integrated incorporating Hazard and Operability Study (HAZOP). Markov process, and dynamic Bayesian Network (DBN), which would foresee the evolution of system from the point of its degradation to predict the time at which it will lose all its functions. Another respondent was asked about planning and maintenance selection, to which they replied:

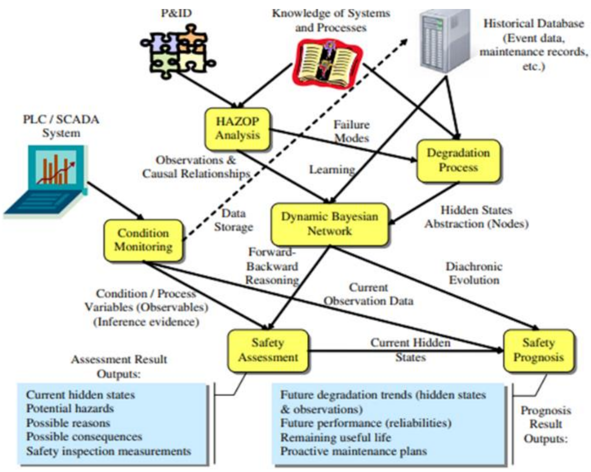

Figure 3. Challenges in Safety Prognostic Technology

"High end methods are usually not applied in petroleum industries, because industries have manpower working from different backgrounds who may not be able to comprehend the usage. Instead, we train them on standard HAZOP models".

This technique could be viable for large-scale equipment whose replacement is arduous. Following is a simplified diagram of the integrated system in Figure .3. From Figure 3. Process flow diagram for the proposed integrated method for safety pre-warning development Source (Hu, Zhang, Ma, & Liang, 2010)

Some prominent challenges petroleum industries experience in implementing suitable prognostic technique, are selection of correct parameters to be measured, understanding of systemic behaviour of equipment over time into a meaningful decision support system to minimise the role of human intervention (Sun, Zeng, Kang, & Pecht, 2012). In this respect, (Tiddens, Braaksma, & Tinga, 2015) highlight an ideal framework for the abovementioned system. In this respect, participants were asked about challenges they face and viability of future technologies in safety prognosis. A participant responded that:

"Although high-end technologies have started making their way in our industry. But big data and AI still have a long way to go before integrating with petroleum refineries".

In this respect, the biggest challenge faced is the precise comprehension of data and its response.

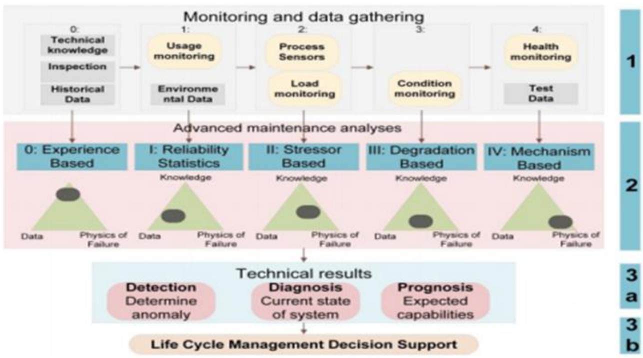

Figure 4. Integration model of data, statistics, and decisions
Source (Tiddens, Braaksma, & Tinga, 2015)

From the diagram and literature, it is apparent that petroleum industries lack integration of second and third tiers of decision support system i.e. the statistical results are not concomitantly utilised in equipment performance. Furthermore, in fault diagnosis systems, issue is faced in detection of early fault phenomenon, because field engineers in refineries are unable to separate the noise from characteristic weakness symptoms (Skaf, 2015). Additionally, samples of one fault detection are usually unique not only to the equipment but the case itself. Therefore, challenge is faced in accurate establishment of identification models. Although decision support tools (DSTs) minimise the unplanned downtime in operations maintenance, however, precise degradation analysis for every equipment is challenging, since it requires intelligent systems for diagnosis and forecasting (Skaf, 2015). When participants were asked about decision support tools in their refineries, it was revealed by one participant that:

"We do not deal with decision support tools as extrinsic elements. Instead they are built in in our machineries, and provide us guidance on how to proceed after a failure detection".

Intelligent systems require vast libraries of data regarding past behaviour of the refinery equipment. Currently, processing plants, specifically petroleum refineries are facing challenge of integration of data recorders into decision platform, because second-to-second monitoring of processes and equipment produce tremendous amount of data, whose processing negatively impacts computers' processing time, leading to delay in prognostics (Xu , et al., 2019). This challenge mandates to be solved through developing advanced automated data selection and analysis strategies to identify the right data for the execution of prognostics models. In furtherance, majority of implemented prognostic models focus on point-prognostic; targeting a single equipment or area. However, high level prognostic efficiency and precision requires analysis of the entire system (Skaf, 2015). This is a major challenge due to lack of exchanged information among different equipment, and limitation of equipment data bases to include prognostic data of other equipment.RESult and discussion

IV. Results and Discussion

According to (Müller & Oehm,, 2019), in most of the complex engineering projects, products and processes such as transportation system and gathering, compressors and pumps in the long-distance pipelines, close relationship to oil and gas production, and various chemical equipment, technological advances are increasing at a rapid pace. (Zhong, Han, & Han, , 2019) expound that, one of the effective technological integration in the field of engineering has been identified named as safety prognostic technology based on data integration methodology, as analysed in above section. This is useful for resolving the challenges pertinent to complex projects. However, aforementioned analysis shows that efficient diagnostics and prognostics systems require collection of tremendous amounts of data from each of the component of the processing plant. To promote data collection and transmission, techniques of machine learning and AI-based intelligent diagnostics are proposed, which would further need modifications to become implementable in petroleum industries.

conflict of Interest

No conflict of interest claim by author

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It can be concluded from this research that safety prognostic technology is playing a major role in many aspects for the good progress in further development of knowledge and technology. The safety status is usually determined by its current, future as well as historical states considering the various time-variant and dynamic states. These can be effective in tracking the dynamic states and predicting the probable danger in the future. In addition, in order to overcome the disadvantages of traditional approaches of safety, prognostic technology is prone to produce false alarms as well as provide an assessment of adaptive online safety consisting of dynamic weighting scheme. These consequences can be catered to by the self-control system of safety prognostic technology that reduces the chances of accidents by failure propagation behaviour. In order to integrate decision support system, it was revealed from literature review that refineries should develop their customised planning tools. Further, in order to expedite response system, organisations should plan and prioritise equipment for the prognosis procedure, which will significantly reduce time delays, and thus save equipment functionality.

In the future, the current study can be conducted by the application of quantitative methodology. This can be attempted by presenting an extensive analysis of monitoring the fault systems and identifying the root cause of faults. Additionally, further research can also be useful in pursuing the safety prognosis by the integration of abnormal event identification and online monitoring, data-driven or model-driven evaluation of degradation by predicting fault trends. Moreover, the study can be useful for future researchers who aim to examine the effects of safety prognostic technology for different petroleum projects.

References

[1] Basias, , N., & Pollalis, Y. (2018). Quantitative and qualitative research in business & technology: Justifying a suitable research methodology. , pp. Review of Integrative Business and Economics Research 7., 91-105.

[2] Beer, A., & Faulkner , D. (2014). How to use primary and secondary data. . In Handbook of Research Methods and Applications in Spatially Integrated Social Science. Edward Elgar Publishing.

[3] Bigliani, R. (2013). Reducing risk in oil and gas operations. IDC Energy Insights., 1-15.

[4] Bousdekis, , A., Magoutas , B., Apostolou, D., & Men. (2018). Review, analysis and synthesis of prognostic-based decision support methods for condition based maintenance. . Journal of Intelligent Manufacturing, 29(6), 1303-1316.

[5] Epelle, E., & Gerogiorgis, D. (2020). A review of technological advances and open challenges for oil and gas drilling systems engineering. AIChE Journal, 66(4), 16842.

[6] Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. African Journal of Emergency Medicine, 7(3), 93-99.

[7] Ershaghi, I., & Paul, D. (2017). October. The changing shape of petroleum engineering education. In SPE Annual Technical Conference and Exhibition. OnePetro.

[8] Grubic, T., Redding, L., Baines, T., & Julien, D. (2011). The adoption and use of diagnostic and prognostic technology within UK-based manufacturers. . Proceedings of the institution of mechanical engineers, part b: journal of engineering manufacture, 225(8.

[9] Hameed, H. (2020). Quantitative and qualitative research methods: Considerations and issues in qualitative research. . The Maldives National Journal of Research, 8(1)., 8-17.

[10] Hasheminasab, H., Gholipour, Y., Kharrazi, M., & Streimikiene, D. (2018). A novel Metric of Sustainability for petroleum refinery projects. Journal of Cleaner Production, 171,, 1215-1224.

[11] Horowitz, G., Faundez, E., Maestri, M., & Cassanello, M. (2014). Fault diagnosis in oil wells. In SPE annual technical conference and exhibition. Society of Petroleum Engineers.

[12] Hu, J., Zhang, L., Ma, L., & Liang, W. (2010). An integrated method for safety pre-warning of complex system. . Safety science, 48(5),, 580-597.

[13] Knegtering , B., & Pasman, H. (2009). Safety of the process industries in the 21st century: A changing need of process safety management for a changing industry. Journal of Loss Prevention in the Process Industries, 22(2), 162-168.

[14] Kordestani, M., Saif, M., Orchard, M., Razavi-Far, R., & Khorasni, k. (2019). Failure prognosis and applications—A survey of recent literature. IEEE transactions on reliability.

[15] Moir, K., Niculita, O., & Milligan, W. (2018). Prognostics and health management in the oil & gas industry–a step change. In Proc. PHM Soc. Eur. Conf (Vol. 4, No. 1., 1-18.

[16] Møyner, O., Krogstad , S., & Lie, K. (2015). The application of flow diagnostics for reservoir management. . SPE Journal, 20(02), 306-323.

[17] Müller, R., & Oehm,, L. (2019). Process industries versus discrete processing: How system characteristics affect operator tasks. Cognition, Technology & Work, 21(2), 337-356.

[18] Neuendorf, K., & Kumar, A. (2015). Content analysis. The international encyclopedia of political communication, 1-10.

[19] Patel, H., Prajapati, D., Mahida, D., & Shah, M. (2020). Transforming petroleum downstream sector through big data: a holistic review. Journal of Petroleum Exploration and Production Technology, 10(6),, 2601-2611.

[20] Pham, B., Agarwal, V., Lybeck, N., & Tawfik, . (2012). Prognostic Health Monitoring System: Component Selection Based on Risk Criteria and Economic Benefit Assessment (No. INL/CON-11-23571). Idaho National Laboratory (INL).

[21] Rolls-Royce. (2009, September 23). TotalCare is described in the RollsRoyce website:. Retrieved from Rolls-Royce plc: www.rolls-royce.com/civil/services/ totalcare

[22] Sanni , M. (2018). Petroleum Engineering: Principles, Calculations, and Workflows . John Wiley & Sons (Vol. 237).

[23] Skaf, Z. (2015). Prognostics: Design, implementation, and challenges.

[24] Stecki, J., Cross, J., Stecki , C., & Lucas, A. (2012). Autonomous Prognostics and Health Management (APHM). European Conference of Prognostics and Health Management Society.

[25] Sun, B., Zeng, S., Kang, R., & Pecht, M. (2012). Benefits and challenges of system prognostics. IEEE Transactions on reliability, 61(2), 323-335.

[26] Tewari, R., Dandekar, A., & Ortiz, J. (2018). Petroleum Fluid Phase Behavior: Characterization, Processes, and Applications. CRC Press.

[27] Tiddens, W., Braaksma, A., & Tinga, T. (2015). The adoption of prognostic technologies in maintenance decision making: a multiple case study. Procedia CIRP, 38,, 171-176.

[28] Vogl, G., Weiss, B., & Helu, M. (2019). A review of diagnostic and prognostic capabilities and best practices for manufacturing. Journal of Intelligent Manufacturing, 30(1),, 79-95.

[29] von Plate, & M. (2016). Big data analytics for prognostic foresight. In SPE Intelligent Energy International Conference and Exhibition. Society of Petroleum Engineers.

[30] Xu , G., Liu, M., Wang, J., Ma, Y., Wang,, J., & Li, F. (2019). Data-driven fault diagnostics and prognostics for predictive maintenance: A brief overview. In IEEE 15th International Conference on Automation Science and Engineering (C.

[31] Yagiz, S., Gokceoglu, C., Sezer, E., & Iplikci, S. (2009). Application of two non-linear prediction tools to the estimation of tunnel boring machine performance.). Engineering Applications of Artificial Intelligence, 22(4-5, 808-814.

[32] Zhang, L., & Hu, J. (2013). Safety prognostic technology in complex petroleum engineering systems: progress, challenges and emerging trends. Petroleum Science, 10(4), 486-493.

[33] Zhong, K., Han, M., & Han, , B. (2019). Data-driven based fault prognosis for industrial systems: a concise overview. IEEE/CAA Journal of automatica sinica, 7(2),, 330-345.

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