QUALITY MANAGEMENT AND FAILURE ANALYSIS APPLIED TO ONSHORE WELLS

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ABSTRACT: Onshore oil wells are active that deserve attention to their failures, as this generates production loss to the return of the well and equipment repair costs and probe intervention to reestablish the well -equipping system. Therefore, proposing measures to extend the life of the wells of wells and reduce the time of the standing well awaiting intervention are important to improve the financial result of the concessions. This work shows how quality management tools (histogram, Ishikawa and Pareto) and fault analysis (causes and effects) were applied to the equipment that brought wells the failure between 2014 to 2018, in the Sergipe terrestrial fields and that Measures have been taken to improve the MTBF (Mean Time Between Failures) of the wells in order to improve the economic result of the concessions. With this study it was concluded that the use of production column coating technology and the use of pumps suitable for the corrosive environment was essential for reducing the number of wells failure and that with the application of quality management tools It has a better view of the information to monitor the failures.

KEYWORDS: Onshore Wells, Quality Management, Failure Analysis.

INTRODUCTION

Onshore oil production is predominant in the world scenario and therefore studying ways to increase its efficiency becomes important to companies in the sector. Thus, it is interesting to conduct studies on improving the performance of lifting systems, as it is the elements that have a high cost to replacement when failure and greater technical complexity for those who perform their projects in land units during the life of the facilities in the life phase of production, Chaves (2018).

In order to improve the life of the equipment used to raise fluids in the wells, it is necessary to apply failure analysis concepts, maintenance and reliability until a level of operating time compatible with the expected one reaches for each Method of elevation according to the literature of the sector, Dantas et al. (2009). Sergipe and Alagoas Business Unit (Un-Seal) of Petrobras used these concepts and created a quality management system for failure analysis and increased time between wells from a computerized computer system with management tools maintenance and best practices of the international industry.

The main artificial elevation methods used in the world today are the mechanical pump (BM), the Progressive Cavities Pump (BCP), the Submerse Centrifugal Pump (BCS) and Gas-Lift, Bastos (2017) and Chaves (2018). These methods are endowed with moving parts and components that wear out as a function of use, operating conditions and operating time. Therefore, it is important to make the correct use of each item descended in the compositions used by the wells in order to extend the life of the scheme as a whole and thus obtain a lower cost with well maintenance, be this cost related to acquisition and replacement of equipment or the cost of intervention with probe, Rodrigues and Da Silva (2005).

Petrobras operates some producing fields in the state of Sergipe from Un-seal, and the fluids produced are medium or heavy oil, with BSW most of over 90% and Gas-Oleum ratio (RGO) in the range of 50 SM3/m3. The fluids produced contain high H2S contents in the gaseous fraction, sometimes reaching 5000 ppmv, and CO2 with contents of up to 30% and with a water produced with high salinity where some cases reaches 300,000 ppm of salts (chlorides). These characteristics lead to a high number of failures in producing wells and consequently the cost of maintenance increases, where from 2014 to 2018 about 7568 probe interventions to correct failures and reestablish production in wells.

In order to reduce the number of wells in wells or increase the time between them and based on the study with the fault analysis management system is that Petrobras has developed a production column coating technology that made a significant reduction enabled of fault in wells that suffered from corrosion or friction on the walls of the pipes and thus drilled prematurely. In addition, the study provided the identification of the need to use background pumps with shirts that have greater corrosion resistance and this was made the acquisition and use of brass -made shirts in certain mechanical pump wells.

Thus, this work has as research problem presenting how the quality management methodology for fault analysis in terrestrial wells applied by the team, which maintenance and reliability management elements are applied in order to propose the use of technologies that increase the Average time between failures (MTBF), reduce the average repair time (MTTR - Mean Time to Repair) and which technologies were successful in reducing probe interventions and increased time between failures Petrobras' terrestrial concessions in Sergipe.

DEVELOPMENT

Theoretical Reference

Since there are several ways to rise oil, the mechanical pump is “the most used artificial elevation method in terms of number of facilities worldwide. It is estimated that 90% use the mechanical pumping system to increase well production ”(BASTOS, 2017), being in Petrobras onshore this proportion and therefore stands out the importance of studying this method in relation to others and its Main components that are the background pump, pump rods and subsurface pipes.

Increasing the useful life of wells lifting schemes is a common goal in the sector’s literature, because “motivation owes the large number of intervention in wells due to the presence of structural failures, corrosion, assembly, etc.” (Rodrigues & da Silva, 2005) and Mcintosh et al. (2020) talks about the importance of studies of reliability and maintenance management as ways to increase time between failures, visions that corroborate what is proposed here.

About reliability and maintenance management are several tools that can be used for the purpose of this work. Dantas et al. (2009) comments that “the reliability of equipment or industrial product is the likelihood that it successfully performs its functions, under a specific period of time, without a stop for maintenance or failure”, being this concept important for Wells, because it is the sources of revenue from oil companies, already in relation to maintenance management we can highlight the use of quality management tools: flowchart, panser, Ishikawa diagram, check sheet, histograms, dispersion and letters Control as ways to enable the analysis, perdoná, naimer, souto and goday (2016).

Total quality tools are used to depend on the type of case under analysis, the most frequent in maintenance management for fault analysis the pareat diagram, Ishikawa diagram and the histogram. According to Perdoná et al. (2016) The Pareto Diagram aims to show the items under analysis due to its importance and proportion to the sample as a whole, while the Ishikawa diagram explores and indicates the possible causes of a condition or problem occurring and with This can be used to propose measures to reduce or eliminate the occurrence and the histogram is widely used to show data distribution through a bar chart that indicates how many times a certain fact occurs or repeats. With these tools it is possible to visualize how is the situation of a particular problem under analysis so that it is possible to propose improvement measures.

Methodology

In the present study, an exploratory, quantitative and deductive methodology applied, from a case study with multiple sources of evidence, was used. Of the 6 sources of evidence described in the work of Yin (2014), which are: documentation, file records, interviews, direct observation, participant observation and physical artifacts. In this study, documents, file records and direct observation were used as sources of evidence. How documents were used to evaluate wells evaluation in the company's computerized systems, such as file registration, the historical fault and production of wells and direct observations were made when evaluating equipment conditions directly in maintenance workshops and probe inspection.

The research issues that conducted this work are the ones presented below:

- Which components and factors contribute to failure in elevation schemes in the studied concessions?

- What actions should be performed to reduce the number of fault in wells?

- What is the impact of the changes proposed on the process and the company studied?

It is noteworthy that the above information is only possible to observe because of the Petrobras Wells Management System (Info) and the Quality Management Methodology for Failure Analysis in wells. Below is an illustrative flowchart with the procedure used today by the company:

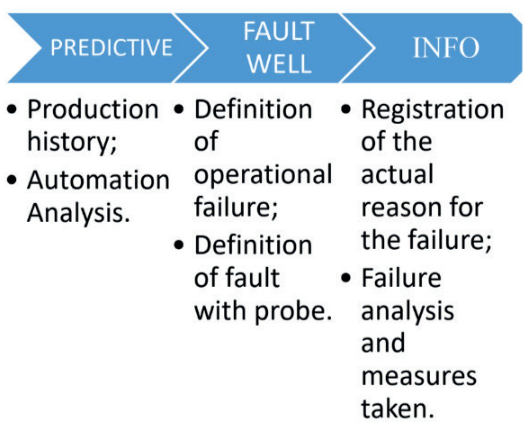

Figure 1. Fault management phases in wells.

Given the quantitative character of the study, the research begins with the survey of historical data to analyze the factors that lead to the fault in wells, with this information being taken from the company's wells management system. For this they were elaborated histograms and diagrams of faults that occurred for reasons and components and with this identified the elements that must be prioritized in the analysis for change.

Then was elaborated Ishikawa diagrams to observe the causes and reasons of failures so that it was possible to propose MTBF improvement actions. At this point, the detailed analysis of the fault modes made from reports prepared by the Petrobras lifting equipment workshops was essential.

In the end, it was analyzed the gains with the changes made and what impacts caused in the concessions studied and how this can be interpreted from financial information, and histograms.

As a limitation we have that the results and analysis focused on the mechanical pump lifting method, as it has greater relevance compared to the total number of failures and thus making it possible to display more detailed information from the results obtained. See below figure 2 which features total methodogram and pizza graph failure failures for the years 2014 to 2019.

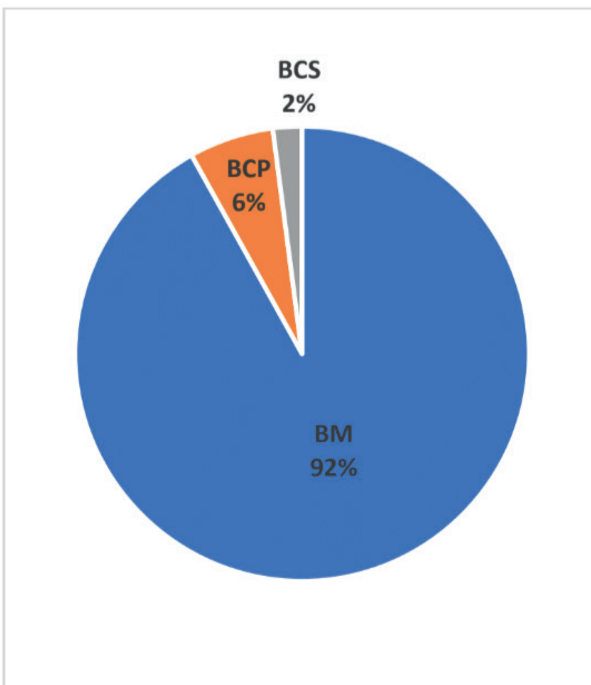

Figure 2 - Representativeness of the Elevation Method by total failures from 2014 to 2019.

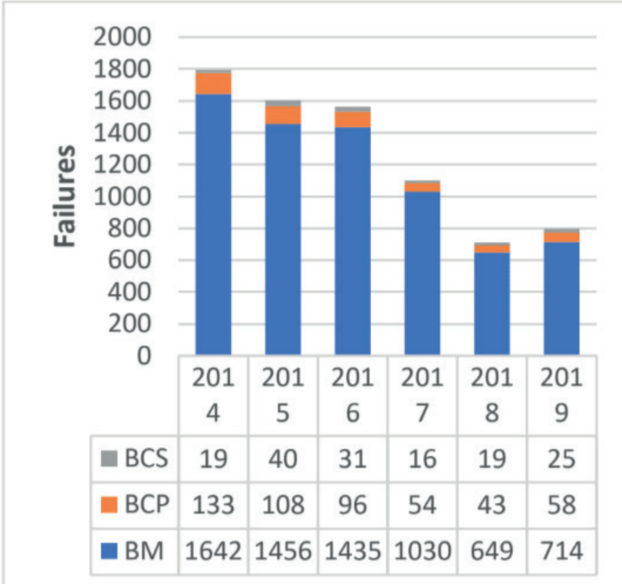

Figure 3 - Number of interventions by elevation method.

RESULTS

The well operating team performs in its routine the verification of production flows by well and measured values of current, pressure, tension, loads, among other parameters depending on the type of pit elevation scheme under analysis. With this, a predictive analysis of the operating condition of the well is performed and appropriate measures when identified deviations. When the failure occurs first an assessment of the well is made by the operating team with surface techniques and then an initial diagnosis of the fault that follows with an intervention with a probe for equipment replacement and verification of the actual cause of failure. Until this step is collected information and it is from this that the info system failure module is fed so that the analysis of mode and failure to propose improvements to future equipment schemes can be done.

The Info system consists of three modules: production, workshop and toyfish. The Workshop Module is responsible for storing failure information in pumps and complements such as filters and seals, the Module Disagreeing stores failure information in tubes and stems and the production module consolidates the information necessary to comply with the quality management method to the Consolidate the production, operation, probe, workshop and disyncination information with analysis of the area engineer analysis and with all the consolidated history. The Workshop and Drive Modules are configured with the taxonomy of equipment to allow the integration of diagnostic, mode and cause data according to FMEA technique. Below is the figure 4 which shows how the FMEA applies to the procedure performed by Petrobras.

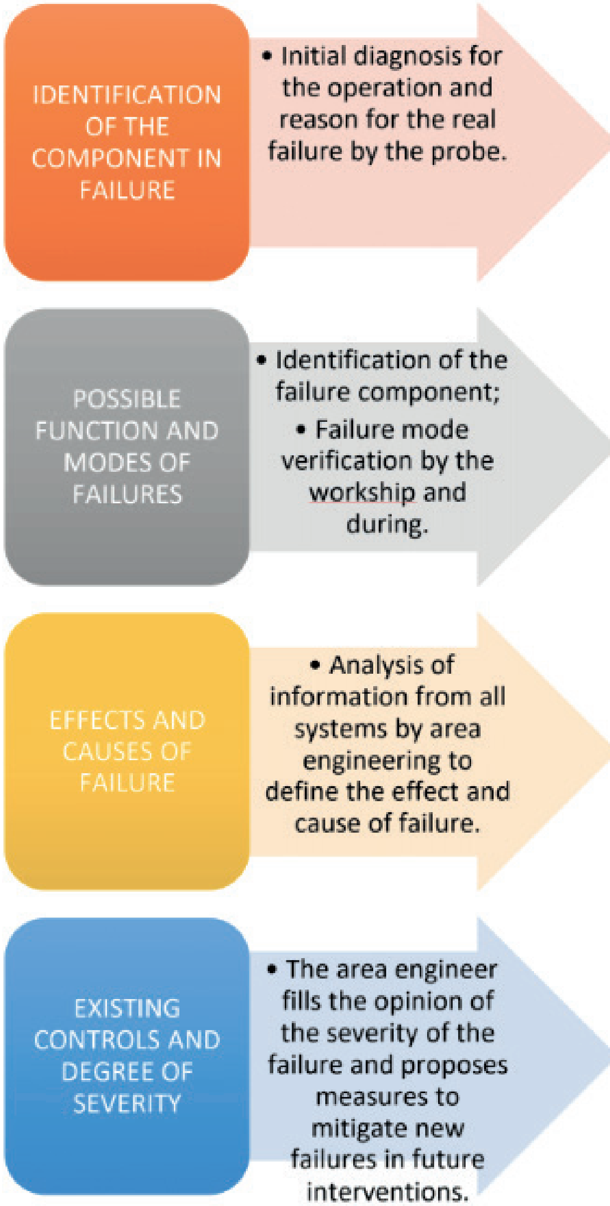

Figure 4 - FMEA Applied to Fault Management in Wells.

It is noteworthy that the consolidated information of the FMEA is stored in the Info Production System and is for historical analysis of the process of fault analysis in wells. Note that without a system thus designed with maintenance and reliability management tools it is not possible to comply with research issues, as the information would not be available for it. See below Figure 1 which is a cut -off system screen cut for a well with the fault analysis already performed by the area engineering.

Data Início	Data Fim	Nº	Sonda	Diagnóstico Intervenção Infopoço	Tipo Oper.	Conf.	Análise de Falha			
							Equipamento	Componente	Modo/Funcionalidade	Causa
01/02/2022	03/02/2022	12	SEM	Haste: Haste	Limpeza/Óleo ou Gás	N4LX	HASTE CURTA	LUVA DE	ESPANADO	INSTALAÇÃO
23/07/2021	26/07/2021	11	SEM	Haste: Haste Partida	Limpeza/Óleo ou Gás	N4LX	HASTE DE BOMBEIO	CORPO	PARTIDO	FLUIDO CORROSIVO
14/07/2017	16/07/2017	10	SPT-34	Bomba de BM: Pistão	Limpeza/Óleo ou Gás	AP9E	HASTE DO PISTÃO	CORPO	APRISIONADO	BAUXITA
06/12/2016	07/12/2016	9	SPT-59	Coluna: Furada	Limpeza/Óleo ou Gás	BEDW	TUBO	CORPO	FURADO	FLUIDO CORROSIVO
21/06/2016	22/06/2016	8	SPT-130	Haste: Haste Partida	Limpeza/Óleo ou Gás	B5P1	HASTE DE BOMBEIO	CORPO	PARTIDO	FLUIDO CORROSIVO
04/11/2015	06/11/2015	7	SPT-55	Coluna: Furada	Limpeza/Óleo ou Gás	KB1W	TUBO	CORPO	FURADO	FLUIDO CORROSIVO

Figure 5 - History of CP-1764-SE-U.

Observação Especial:	Ação Bloqueadora:	Observação:
(05/2017): Efetuado recanhoneio dos intervalos compreendidos entre 595 e 610,5 m. Realizado TCZ entre as zonas. Realizado RP-01 das zonas RIA / TQR + MUR/OIT topo + MUR/OIT base (595,0 - 658,0 m), em conjunto:PE= 52,63 Kgf/cm² e Temp.46,50C. Efetuado fraturamento hidráulico-ácido LZ das zonas RIA/TQR + MUR/OIT topo (595,0 - 610,5 m), em conjunto. A diferença da checagem do fundo com raspador a 651,7 m e luva denteada a 659,3 m confirma provável restrição a 651,7 m. (01/2015): Restauração/Acidificação(jateamento ácido). Cortado cimento até 662 m. Canhoneados os intervalos: 626,5/627,5m - 2 Picos, 631,5/632,5m, 650,5/652,0m e 656,0/658,0m. Acidificados os intervalos(Jateamento ácido): 595.0/610.5m e 626.5/658.0m.	Instalar filtro de areia, colocar bomba acima dos canhoneados e substituir coluna de tubos por coluna revestida na próxima intervenção. Avaliar o uso de anticorrosivo de forma contínua. Avaliar substituição do grau da haste de bombeio.	100% DAS HASTES DE 3/4" SAÍRAM COM PARAFINA NO CORPO. 100% DAS HASTES DE 5/8" SAÍRAM COM SCALE E CORROSÃO NO CORPO. A ÚLTIMA HASTE SAIU COM ABRASÃO NO CORPO. EFETUADO TESTE COM A BOMBA NA SUPÉRFICÍE COM 800 PSI NEGATIVO, PORÉM IDENTIFICADO PROBLEMA DE BOMBA SIGAME: bomba sucateada.

Figure 6 - Data from the CP-1107-SE-U

Note the increase in campaign time between interventions after installation of the coated column on 07/16/2017. The well stopped having interventions by hole in the column and started to have interventions on broken rods, but with a much longer campaign time. See by the example above that with this system it is possible to observe the history of the Summary Table Failure Analysis and clicked on any of the lines it is possible to check the comments of the engineer who analyzed the failure and thus check the measurements and information which were identified as important. Now see Figure 6 below the comments when clicking on the intervention of probe number 12 of the CP-1107 well, which suffered from background pump problems so bass MTBF and that after the comments made by the engineer started to have his mechanical scheme changed and With this your background pump MTBF has significantly improved.

Note that the engineer makes an analysis of the components with information from all systems and gives the opinion on the actual reason for the failure and what measures should be taken so that no further failures occur.

With the history generated by this system it is possible to meet the first research question that is to define which components and factors contribute to the failure in lifting schemes in the concessions studied from the exposure of the 2014 failure causes of the subsurface components of subsurface of BM is presented in the form of Pareto diagrams as can be seen in figure 7, 8 and 9 below.

It can be seen that corrosion and abrasion are the main reasons for failure and therefore the Ishikawa diagram for these problems as shown in Figures 10, 11 and 12 was made.

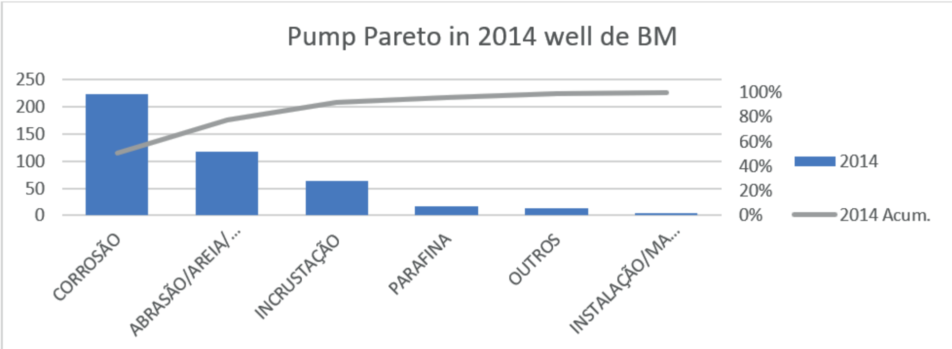

Figure 7 - Pareto diagram of the causes of background bombs in BM wells in 2014.

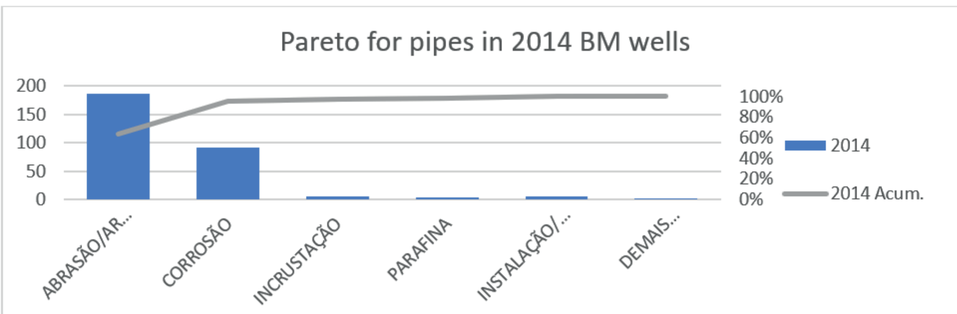

Figure 8 - Pareto diagram of pipe failure causes in BM wells in 2014.

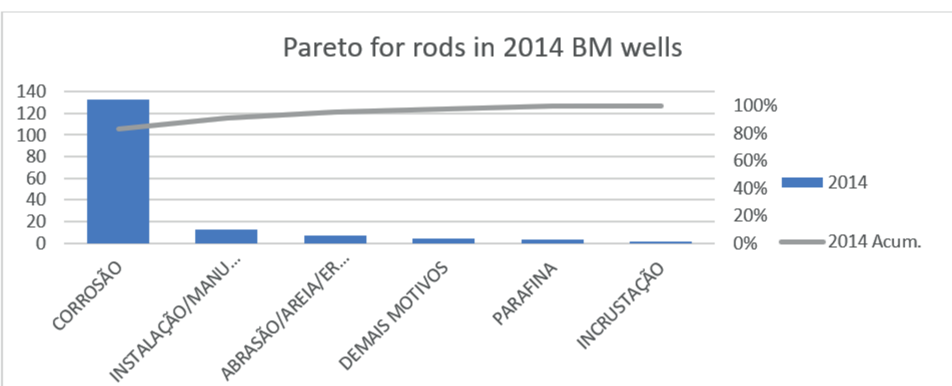

Figure 9 - Pareto diagram of fault causes in rod in BM wells in 2014.

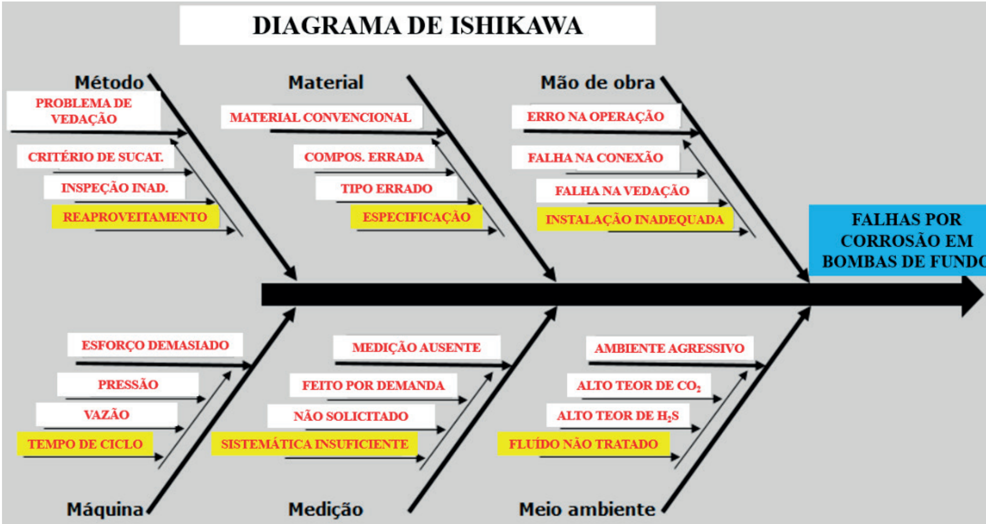

Figure 10 - Ishikawa diagram for corrosion pump failure.

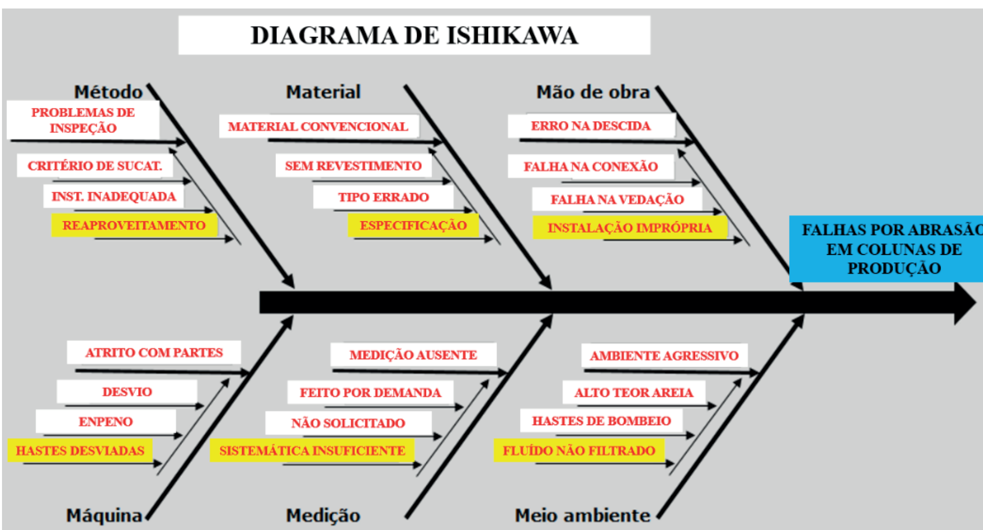

Figure 11 - Ishikawa diagram for abrasion pipe failure.

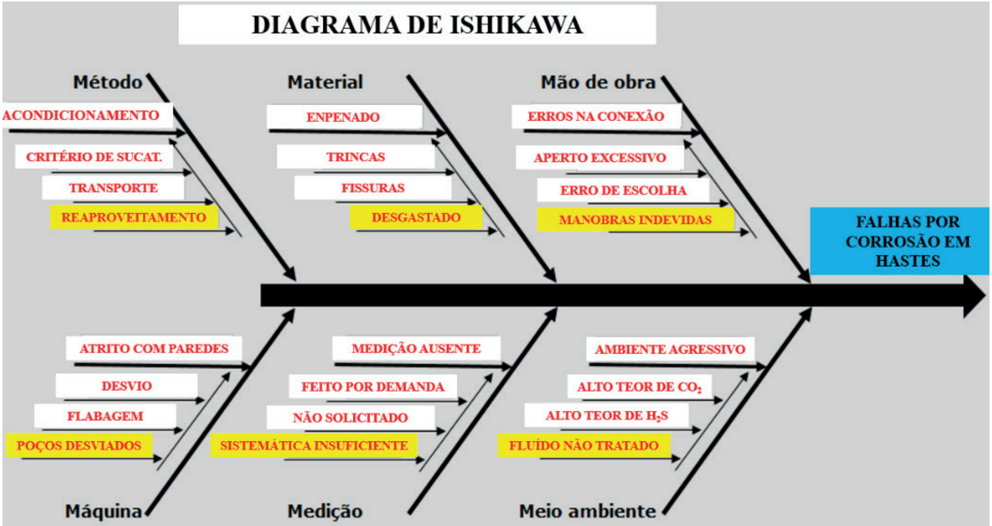

Figure 12 - Ishikawa diagram for rod failure by corrosion.

See that with the elaborate diagrams it is easy to notice the roots of fault motifs and thereby proposing improvement actions. It was based on this that the team of engineers of the production of Petrobras Sergipe proposed as improvement measures the installation of columns coated with polyethylene and polyamide to reduce the number of failures in corrosion production pipes, the use of pumps with Brass Shirt and a set of components suitable for corrosive environment to reduce bottom bombs failures and the proposal to use noblest metallurgies pump rods to reduce pump stem faults, as well as several other measures for resolution of the Problems encountered in the Ishikawas, elucidating the second research question.

From 2014 to 2018 substantially applied to corrosion adapted pump technologies and columns coated as explained above, but it was not possible to apply rods with new technologies. With this, the results below were obtained, as seen in Figures 13, 14 and 15. 2019 did not enter the analysis because it did not have all the analyzes filled when elaborating the study.

From histograms we can see a significant reduction in the number of failures in production columns and background pumps as expected for the changes made in the schemes. The rods got the same failure profile and it is interesting to note that the main mode of failure was the party. With the values below and with the natural trend of lifting the number of failures by scrapping the material used, we can propose conservatively that there was a reduction in the number of failures in the following years compared to the base year 2014 of about 1000 interventions with Probe per year, where as an intervention costs an average of U$$ 26,800, we can say that the changes generated an savings of up to U$$ 26,8 million per year for the company only with cost reduction, but it is worth noting that there is production gain associated with the execution of less failure and higher MTBR.

It is important to emphasize that the number of wells already drilled in the Petrobras unit under analysis exceeds 3,000 units, but due to feasibility and strategy in 2014 we had about 1500 wells in operation and that in 2018 we had 1200 wells in operation, thus representing An average MTBF of 10 months in 2014 and 18 months in 2018, being considered the MTBF relating to only interventions with probe, not being considered those of crane.

CONCLUSIONS

Based on the results found we can see that the research questions were answered, as the quality management of wells was applied, the fault historicals were analyzed, then the Ishikawa of the main reasons for failure and at the end of the reduction were elaborated. In the number of fault by histograms with the financial results achieved that are important to validate the study. As can be seen, polyethylene and polyamide -covered spine technologies and corrosive environments pumps were successive in significant reduction in the number of faults in wells and showing the importance of adopting this practice by oil and bus companies. As a suggestion for future work we have to improve the technology used in pump rods and make more research on other failed reasons not listed in the analysis.

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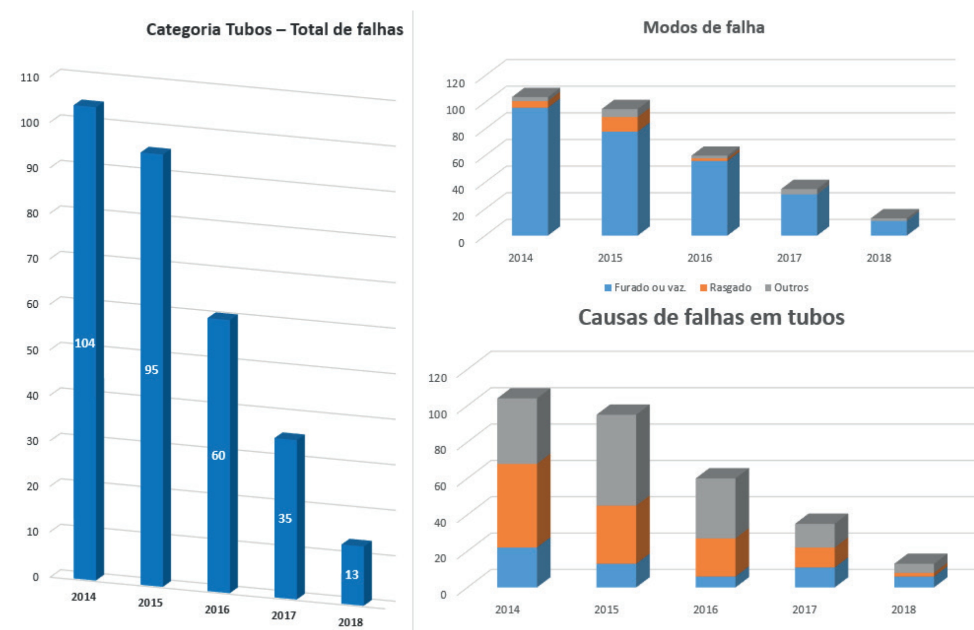

Figure 13 - Situation of pipe failures as a function of time.

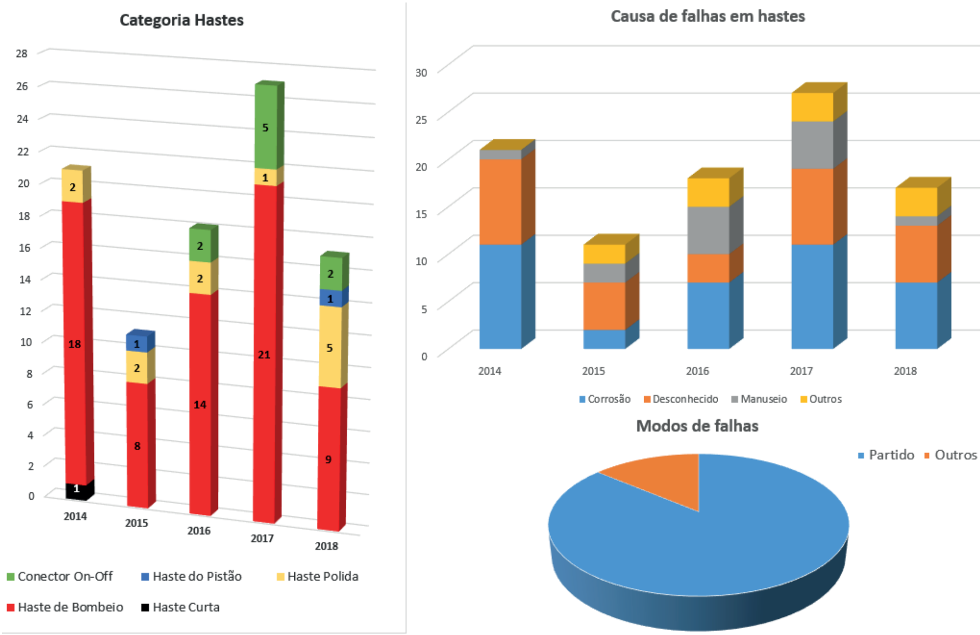

Figure 14 - Situation of rod failures as a function of time.

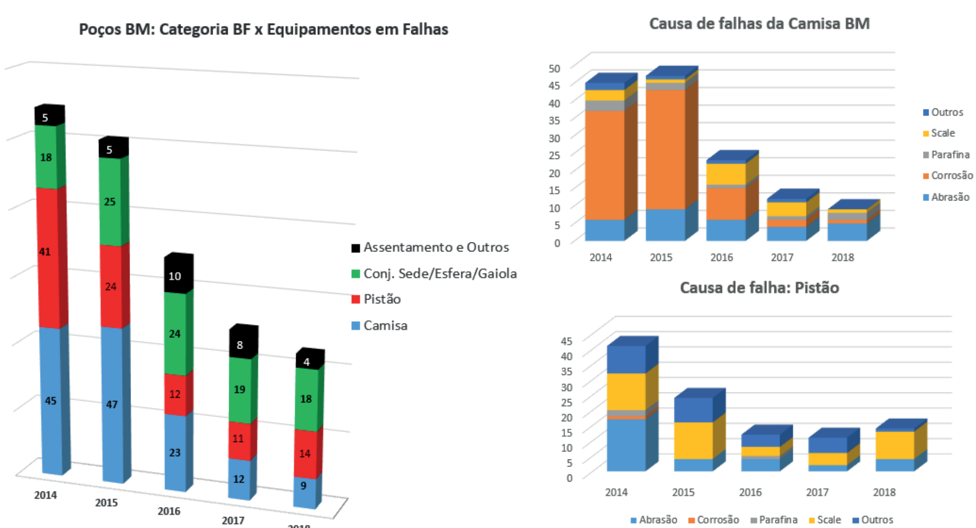

Figure 15 - Situation of bombs failure as a function of time.

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