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IMPACT OF DRILLING EQUIPMENT QUALITY CONDITION AND EXPERTISE AVAILABILITY ON WELL DRILLING COST- A CASE STUDY OF OLKARIA GEOTHERMAL FIELD

Paul Kevin Omondi Otieno,
Kenya Electricity Generating Company
P.O BOX 785-20117, Naivasha
Kenya
POmondi@kengen.co.ke

ABSTRACT

Geothermal drilling is an expensive activity whose cost have a direct bearing on the final cost of a geothermal project. It is desirable to have no downtime during drilling. Such a well would take less time to drill and even hasten delivery of a geothermal project. It is therefore important to optimize the drilling time so as to reduce the cost of drilling the well. To achieve this, an analysis of the cause of non-productive time caused by equipment downtime (which forms the bulk of NPT recorded in Olkaria) incurred while drilling a well is necessary so as to identify areas of improvement. This paper highlights the causes of non-productive time occasioned by equipment downtime through drilling time analysis of nine wells drilled in the Olkaria field in Kenya with the view of improving on the causing factors and hence saving on costs.

Keywords: Downtime, drilling equipment, drilling time analysis

1. INTRODUCTION

Downtime is an undesirable outcome in any operation. It not only leads to loss of money in terms of costs but also reputation especially in this era of companies venturing into contract drilling which is very competitive. In this paper, downtime or non-productive time (NPT) is defined as that time that the rig is not involved in actual well drilling i.e. not gaining meters. There are several causes of this rig downtime (Dew and Childers 1989), from bad weather, fire, tripping in and tripping out, wait on water, wiper trips etc. however, the focus of this paper will be downtime occasioned by equipment failure. Nyota (Nyota et al, 2015) established that most wells drilled in Olkaria incur a 24% downtime arising from several factors including but not limited to equipment failure, tripping in and out of hole, drill on cement etc. More than half of this time (15% of the overall) was attributed to equipment unavailability during the drilling making it the major cause of downtime at the rig. A critical analysis therefore has to be made to find out the causes of this equipment unavailability. By asking questions about the maintenance practices, quality of equipment, availability of spares, environmental conditions, handling of the equipment etc. We can gain insight and improve the availability of these equipment.

The data used is obtained from the drilling time analysis reports and daily maintenance reports of nine wells drilled in Olkaria. These wells are OW-46A, OW-39, OW-48A, OW-39B, OW-37B, OW-732B, OW-53, AW-01 and AW-02. All wells drilled to a depth of three thousand meters. By collaborating the drilling time analysis reports and the maintenance reports, a downtime analysis is obtained of the actual equipment that was out, how long it was out and what was the reason it was out. This way a classification of equipment downtime can be made and a method of handling the downtime formulated. In addition, the historical approach of handling the downtime is also established with the view of improvement.

2. METHODOLOGY

The data used herein is drawn from the individual well reports after completion. Both drilling time analysis reports and maintenance reports data are used. The data is thereafter analysed in excel by use of bar graphs and pie charts to establish the main equipment failing and the causes of the resulting downtime. Not all equipment are considered in the analysis. The critical equipment are chosen for study to establish which of them contribute highest to the downtime. Here critical equipment is that which is responsible for the majority of the downtime as recorded by the rig maintenance and drilling records. To confirm our choice of equipment selection, a Pareto analysis is conducted. Pareto (Pareto, 1896) states that about twenty per cent (20%) of the sources cause eighty per cent (80%) or more of the total downtime. This therefore means that we expect to find that a small number of sources to cause the most of the downtime. To better understand these results, interviews of staff at the rig site were conducted. The results of these interviews form the main source of information on how to improve on the findings from the analysis of the data obtained.

2.1 Equipment selected for study

The equipment selected were as follows for study;

1. Rotary Table
2. Draw works
3. Top Drive
4. SCR
5. Mud Pumps
6. Service loop
7. Air Compressors
8. Generators
9. Drilling parameters monitoring and control instruments
10. Drill string

These equipment were selected because at any given time, if any of them failed the drilling would be stopped. Assumption is made that there are no redundant machines (even though some of the machines have redundancies) so as to establish the highest failing equipment. Moreover, it was established that ninety nine percent (99%) of the equipment failures recorded were due to these equipment.

2.2 Limitation

The data presented was first qualitatively analysed by finding inconsistencies in reporting. This especially arose from conflicting operational and maintenance data. However, these incidences were found to be minimal. Since the data is from the rig reports drawn from primary data recorded at site, the accuracy of the findings are limited to the secondary reports. Any misreporting that might have been undetected in the qualitative analysis is thus transferred to the final findings. It was also established that downtime lasting less than thirty minutes always goes unreported unless it reoccurs frequently. There is therefore no record of such data included in the analysis.

3. DATA ANALYSIS

Nyota et al established that 24% of downtime (or non-productive time) occurred in Olkaria. Fifteen percent (15%) of the overall drilling time downtime was attributed to downtime occasioned by equipment failure or unavailability. This forms sixty two point five per cent (62.5%) of the total downtime. The equipment recorded to have contributed ninety nine percent of this downtime are as follows and forms the major area of focus of study.

3.1 Major contributors to downtime occasioned by equipment

Equipment	Per cent downtime occasioned (%)
Rotary Table	2
Draw works	5
Top Drive	29
SCR	15
Mud Pumps	2
Service Loop	1
Air Compressors	25
Generators	1
Drilling parameters monitoring and control instruments	18
Drill string	1
Total	99

Table 3.1 Contribution of the critical equipment to the overall equipment downtime recorded

The data shows that the top drive, air compressors, SCR and the rig instrumentation are the major source of equipment failure at the rig. A Pareto analysis is conducted as follows;

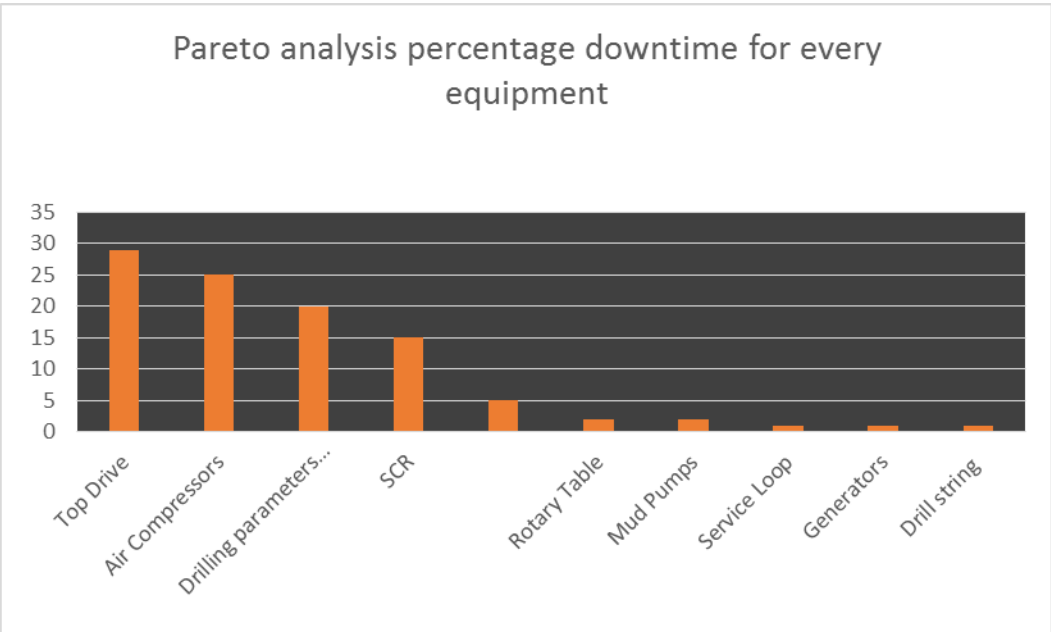


Figure 3.1 Pareto analysis graph

It is evident that only four of the equipment cause the highest downtime. The four (Top drive, air compressors, drilling parameters monitoring and control instrumentation and SCR) cause a combined total of eighty seven per cent (87%) of the overall downtime.

3.2 Root Cause analysis of downtime occasioned by equipment by occurrence

The reasons for equipment failure or unavailability need to be established. The following is a presentation of the data based on reasons identified by rig crew on reasons for downtime occasioned by equipment. The main reasons for equipment downtime were identified as follows;

- Poor maintenance
- Wrong operation
- Unavailability of spares
- Procurement procedures
- Poor Quality
- Unavailability of expertise
- Others e.g. Fuel quality, drilling mishaps etc.

Root Cause of downtime	Number of Events	Percentage (%)
Poor maintenance	69	33.17
Wrong operation	42	20.19
Unavailability of spares	27	12.98
Procurement procedures	31	14.90
Poor Quality	10	4.81
Unavailability of expertise	23	11.06
Others	6	2.88
Total	208	99.99

Table 3.2 Analysis of root cause analysis of equipment downtime.

From Table 3.2, it is evident that poor maintenance has the highest number of occurrence. However, the rig staff not agree that it cost the highest downtime even though it had the highest occurrence. Therefore, analysis of the cost of downtime occasioned the root causes was done.

3.3 Cost of downtime occasioned by the root causes

By isolating the root causes and establishing how long each caused equipment downtime over the period of study, the following was obtained. The number of days were calculated in terms of day rate value of KenGen’s drilling cost from the Akiira drilling contract.

Table 3.3 Root causes analysis in terms of costs incurred

Root Cause of downtime	**Cost Kenya Shilling (KES)**	**Percentage (%)**
Poor maintenance	8,309,421.00	12.94
Wrong operation	6,429,397.00	10.01
Unavailability of spares	17,811,094.00	27.74
Procurement procedures	13,974,645.00	21.77
Poor Quality	5,329,644.00	8.30
Unavailability of expertise	10,258,711.00	15.98
Others	2,084,918.00	3.25
Total	64,197,830.00	99.99

4. DISCUSSION

The discussion of the findings are centred on the findings from the data as analysed above with focus on three areas;

1. What are the main causes of downtime occasioned by rig equipment and how severe are they in relation to one another?
2. Which of these causes have the highest implication in terms of drilling time lost?
3. What is the relationship between the frequency of occurrences of the causes and the costs incurred?

4.1 Causes of downtime and Cost implication

Information obtained in Table3.2 and Table 3.3 can be presented in form of a pie chart as below for comparison purposes.

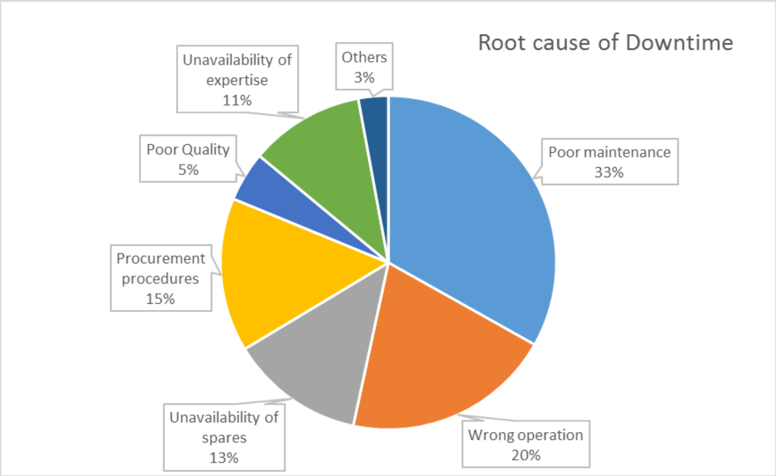


Fig 4.1 Pie Chart representation of root cause analysis

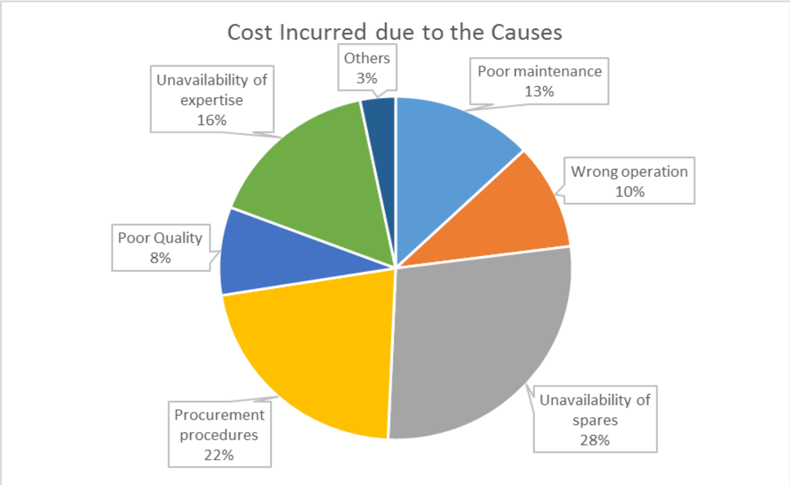
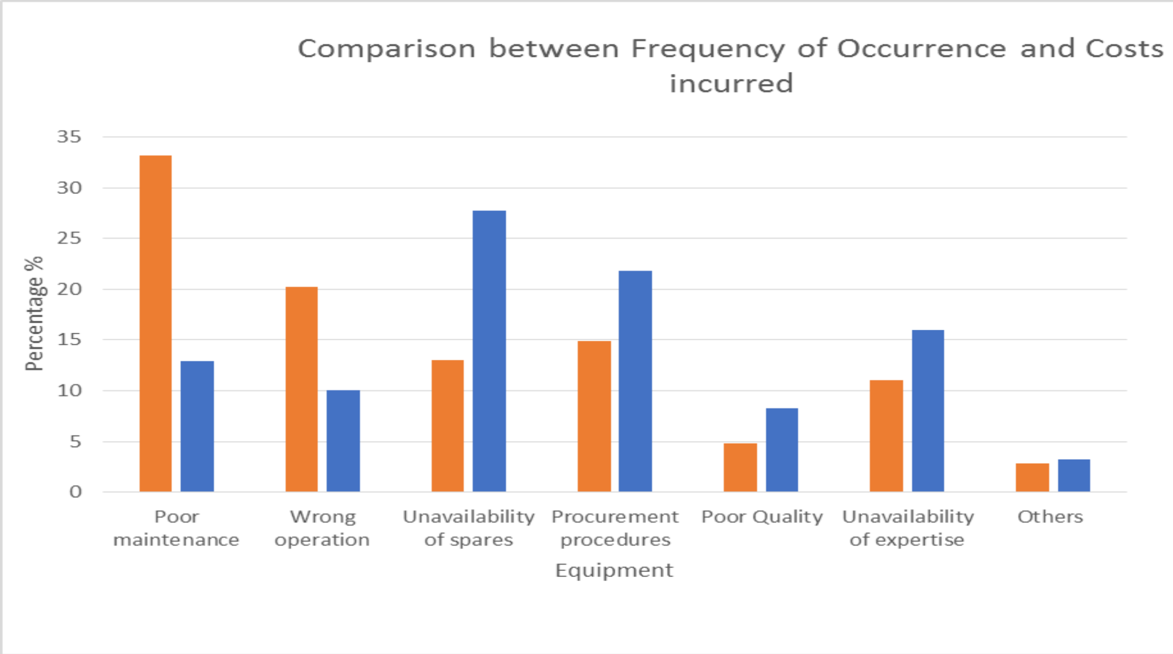


Fig 4.1-2 Pie Chart representation of costs incurred due to the different root causes

From the pie charts, it is clear that poor maintenance is the main cause of the highest events of downtime resulting from equipment unavailability. This accounts for thirty three per cent (33%) of the total events of downtime. These frequent occurrences lead to equipment losing efficiency and also depreciates rapidly without any return on the investment put in it. However, these events are always dealt with within a short time so that no major downtime is incurred. Innovations like equipment modification to adopt to new conditions or use of locally available spares instead of spares that necessitate importation have led to reduced downtime caused by the equipment. Events occurring due to wrong operation is also quite high. Twenty percent (20%) of all events are due to equipment mishandling. Incidences like using an equipment for a job it is not meant for, running a machine past its recommended limits and operator carelessness not only cause downtime but subject the equipment and the user to unforeseen safety hazards. Long procurement procedures, unavailability of spares and expertise are the next largest cause in terms of occurrence. These however are related such that when expertise or a spare is required, procurement must be initiated which often takes long. Sometimes even when the procurement process is fast, the expertise or the spare is not readily available hence long lead time which cause downtime.

On the other hand, the actual costs incurred due to these downtime are not directly related to the frequency of occurrence of the events. From table 3.2 and Table 3.3, it can be seen that frequency and cost are not related. In as much as maintenance had the highest occurrence, it is still not the highest cost incurred in terms of the drilling time cost. It is a major belief that poor/insufficient maintenance is the main cause of equipment downtime hence cost. From the above figures, this is not the case. Poor maintenance leads to equipment downtime in known areas that most of the time the rig staff can handle. Poor/insufficient maintenance frequently arise due to lack of training and unavailability of spares.

Unavailability of spares, procurement procedures and unavailability of expertise costs the most (Fig 4.1-2). This is mainly because the spares and expertise are often required from the manufacturer who are overseas. Coupled with long procurement procedures, the lead time always takes long hence causing the longest downtime. These factors however are not easily controllable due to the high costs involved in trying to mitigate them. Training staff overseas, forming frame work contracts with equipment suppliers and changing our procurement processes cannot be done easily overnight and may sometimes may not be done at all in the case of government entities. Poor maintenance and wrong operation still take twenty three per cent (23%) of the total costs (approximately KES 14.77 Million). These can be managed by incorporating better maintenance plans (time based and condition based maintenance), training the staff on operation and maintenance and increasing the number of staff. The above information can be summarised by the bar graph below;



Key: Brown:→ Frequency of Occurrence Blue: → Costs Incurred

Figure 4.1-3 Comparison of each root cause and costs incurred

5. RECOMMENDATION

From the above discussion the following are recommended;

1. Most of the new equipment currently used in drilling are highly sophisticated and incorporate use of software and other highly specialised control mechanisms. It is therefore important to train staff both how to operate and maintain the equipment. The high frequency of occurrence of equipment downtime due to lack of proper maintenance stems largely from not knowing what is to be done and how to do it hence leading to trial and error when handling the maintenance and operation.
2. Introduce time based maintenance and also condition based maintenance for the high efficiency machines like the air compressors. Khelifi (Khalifi, 1999) states that maintenance can be improved by changing the approach to your normal maintenance. Updating the system often leads to better results. However, a balance must be struck between costs involved, shut down time due to planned maintenance and drilling plans especially when improvement in maintenance leads to extra activities. The results can be monitored to establish trends of improvement or deterioration overtime.
3. Improvement of the procurement procedures. If the process could be made faster while still adhering to the public procurement act. A lot of downtime can be prevented. Adoption of facilities like framework contracts can greatly reduce lead times hence downtime.
4. Development of capacity at all levels including Engineers. The long lead times incurred when waiting to import expertise can be avoided. This requires the company to formulate areas of focus and come up with plans to develop capacity in the areas. In this case, it is clear from the Pareto analysis that the Top drive, SCR, air compressors and drilling controls are the main equipment causing the most downtime hence capacity should be built focussing in these areas first before venturing into the other areas.
5. Co-operation between rig maintenance and drilling operation professionals in the industry. The rig equipment are almost similar in design and operation. The differences are just but manufacturers who have put patents and access controls to secure their market. Co-operation would lead to sharing of knowledge and experiences which would develop everyone.

6. Manufacturer support. There are no drilling equipment manufacturers in Africa. Most of the time even finding an agent is not easy. The manufacturers should come closer and support their rigs. If we would get the manufacturers opening offices say in Nairobi to support the rigs within the great African rift, then the long lead times to acquire spares will be reduced. Moreover, delivering a drilling contract will be easier and our rigs will be able to compete with other international rigs in terms of drilling time.

6. CONCLUSIONS

It was found that poor maintenance was the cause with highest number of occurrence causing equipment downtime which however did not translate to the most time lost during drilling as would have been believed. A combination of slow procurement process and unavailability of spares and expertise from manufacturing company led to the longest equipment downtime. By introducing procurement facilities such as frame work contracting, this gap can be reduced considerably but not eliminated as long as the manufacturers still remain overseas away from the continent.

By adopting several measures to develop capacity and training of staff, the frequency of occurrences can be reduced and hence improvement of equipment availability. Other measures like introducing new maintenance systems from experience of working with the machines at the rig can be implemented and the trend evaluated so as to establish whether improvements are being realised.

Finally, costs incurred due to equipment downtime should continually be analysed to plan for better maintenance, safety of the rig and the personnel. And in this era of contracted drilling it pays to have the most efficient equipment, capable staff and a properly defined way that ensures you have spares and technical support when needed.

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