IJMTST is UGC Approved Journal with Journal Id: 43137

International Journal for Modern Trends in Science and Technology, 8(S04):80-84, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST08S0414
Available online at: https://www.ijmtst.com/vol8si04.html

ReliabilityAnalysis of DTH Drill Bits in consideration with Failure Modes

Annamreddi Swamy | Dhuli Bharat Narasimha | GorripatiYeswanth Kumar | Jalakam Sainath |Satya Prakash*

Department of Mining Engineering, Godavari Institute of Engineering and Technology(A), JNTUK, Kakinada.
*Corresponding Author Email ID: prakashsatya@giet.ac.in

To Cite this Article
Annamreddi Swamy, Dhuli Bharat Narasimha, GorripatiYeswanth Kumar, Jalakam Sainath and Satya Prakash. ReliabilityAnalysis of DTH Drill Bits in consideration with Failure Modes. International Journal for Modern Trends in Science and Technology 2022, 8(S04), pp. 80-84. https://doi.org/10.46501/IJMTST08S0414

Article Info
Received: 26 April 2022; Accepted: 24 May 2022; Published: 30 May 2022.

ABSTRACT

Rock drilling is a common practice in the mining industry. The drilling process with drill bits directly impacts the production rates and shares the economy of the entire mine. A successful drilling operation depends on multiple factors such as operating parameters, type of drill bit, operator skill, and geological conditions. Frequent failure of bits is a severe concern for field engineers and the manufacturing industry. The present study discusses the failure reasons of down-the-hole (DTH) bits in the barytes mine. The life data of the DTH bits have been considered in the study. A reliability-based analysis has been done on bit life data to estimate the bit reliability with respect to different failure modes.

KEYWORDS: DTH bits, Bench heights, Life data, Reliability, bit failure

1. INTRODUCTION

The failure of bits is a severe issue, and its behavior has been discussed in the past. Beste et al. [1] have addressed the behavior of the button bits in different mining conditions. They concluded that the life of a drill bit depends on several factors, including the geological conditions of rock. Beste and Jacobson [2] have studied the microscopic study on button bit using Scanning Electron Microscopy. They proposed the wear and deterioration condition of WC/Co rock drill buttons. Ren et al. [3] have discussed the behavior of rock drill bits in different mining conditions, and they found that the life of drill bits plays an essential role in the drilling method. Liang et al. [4] have discussed the different drill bits available in mine. Their study examined the milled tooth type drill bit thoroughly. DTH, tri-cone, and milled tooth type drill bits are mainly used in mining, and several researchers have studied their constructional features. Prakash and Mukhopadhyay have studied the life of drill bit using reliability analysis by collecting time to failure data from the field [5]. They proposed a new data collection technique and showed warranty-based drill bit data's importance in reliability analysis. Researchers have examined different DTH bits' failure modes byconsidering the wear and microscopic test on failed bits [6]. The DTH drill bit's strength depends on the strength of the inserts. These inserts are embedded on the drill bit surface with shrink fit. The process of manufacturing of these inserts is done with the powder metallurgy technique. Researchers have studied the performance of DTH drill bits by calculating the rate of penetration on overburden. The relation between penetration rate and wear has been examined by Karasawa et al. [7]. The present research discusses the different modes of failure of DTH bits in the barytes mine. This study also determines the reliability of DTH bits by considering the drill bit life data.

2. REALATED WORK

Researchers and scientists have studied the behavior of DTH drill bits in the past. Few researchers have considered the importance of data collection from the field in determining the life of DTH drill bits. The reliable collection of data on failed drill bits is necessary, and it has been discussed by considering a Nevada chart technique in surface mines [5]. Thoman et al. [8] have developed a statistical method to determine the life of DTH bits using the maximum likelihood estimation method. Previous studies discuss the reliability of button bits using a statistical approach. However, collecting reliable data is still a challenging task. The different failure modes are also unpredictable as DTH bits work in an abrasive environment. The rock properties and the operating parameters have been considered in previous research for the analysis of DTH drill bits in various mines. The composition and design of the DTH drill bitalso insist on interest among the researchers. The study

with Field Emission Scan Electron Microscopy and Transmission Electron Microscopy on failed DTH drill bits gives significant results to the research industry. The advancement in nano-technology and surface coating have also increased the reliability or life of such drill bits in the field. However, the data analytics approach has not been considered for the failed bits to understand their behavior regarding different mining locations.

3. PROPOSED WORK

This work considers the study of failed DTH drill bits in a barytes mine. The DTH drill bit life data have been collected from the different mining locations. The reasons for failure have also been studied. The present studydiscusses the data analytics approach using drill bit life data of DTH drill bits in software R. The following flowchart depicts the steps considered in the study.

3.1 Data Collection

The DTH drill bit life data in hours have been collectedfrom the barytes mine situated in Andhra Pradesh. Thefailure conditions of bit in three different situations, suchas ore, white shale, and black shale, have been identifiedin the process of data collection. The collection of reliabledata is always a challenging task. Thus, in the study, thefailure hour of DTH drill bits has been collected withrespect to theirbench number.Table 1representsthefailuredataofDTHdrillbitscorrespondingtotheirfailure conditionsandbenchnumber.

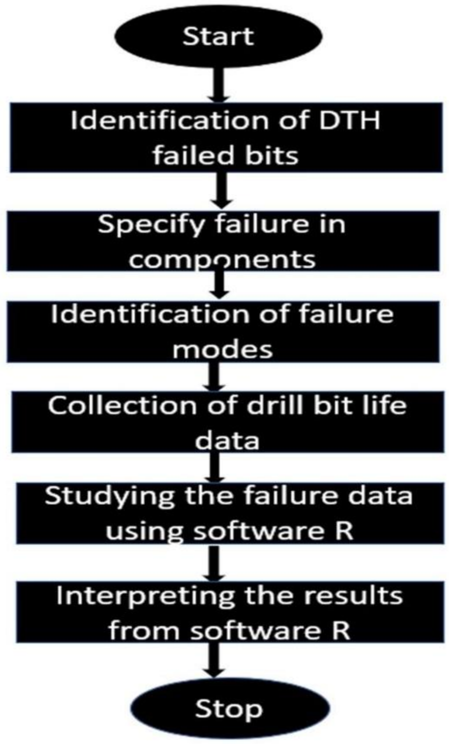

Figure1:Flowchartsdepictthestepsintheproposed work

Table1:DTHdrillbit lifedata.

Sl.no	Drill bitlife inhours	Reasonsoffailedbit	Type ofmaterial	Benchnumber
1	137.6	Highhardnessof strata	Ore	26
2	219.8	Mechanicalwearandtearof buttons	Whiteshale	11
3	183.5	Mechanical wear and tear ofbuttons	Whiteshale	9
4	105.8	Highhardnessof strata	Ore	24
5	89.8	Presenceofjointsinrock	Blackshale	17
6	133	Mechanicalwearandtearof buttons	Whiteshale	9
7	104.5	Highhardnessof strata	Ore	25
8	130.6	Mechanicalwearandtearof buttons	Whiteshale	12
9	111	Highhardnessof strata	Ore	26
10	130.4	Mechanical wearand tear of buttons	Whiteshale	5
11	161	Mechanical wear and tear ofbuttons	Whiteshale	4
12	114.6	Highhardnessofstrata	Ore	27
13	150.2	Presenceofjointsinrock	Blackshale	20
14	272.3	Mechanical wearand tear of buttonsMechanical	Whiteshale	7
15	266	wearand tear of buttons	Whiteshale	10
16	47.2	Highhardnessofstrata	Ore	26
17	131.8	Mechanical wearand tear of	Whiteshale	11

18	184.1	buttonsMechanical wearand tear of buttons	Whiteshale	8
19	78.3	Presenceofjointsinrock	Blackshale	18
20	67.8	Highhardnessofstrata	Ore	26
21	108.1	Presenceofjointsinrock	Blackshale	14
22	65.7	Presenceofjointsinrock	Blackshale	13
23	84.7	Highhardnessofstrata	Ore	25
24	132.6	Presenceofjointsinrock	Blackshale	15
25	111.9	Highhardnessofstrata	Ore	24
26	134.4	Presenceofjointsinrock	Blackshale	22
27	128.6	Highhardnessofstrata	Ore	25
28	113.5	Presenceofjointsinrock	Blackshale	23
29	182.2	Presenceofjointsinrock	Blackshale	19
30	172.1	Presenceofjointsinrock	Blackshale	21

3.2 Failure Modes in DTH drill bits

The International Association of Drilling Contractors (IADC) [9] has categorized the different failure modes in rock drill bits using a grading system. In the study, 30 DTH drill bit life data were collected, and three different types of failure modes were identified. Figure 2, Figure 3, and Figure 4 represent the different types of failure modes in DTH bits.

Figure2:FailedDTHdrillbitduetohighhardnessofstrata

Figure3: FailedDTHdrillbitdue topresence ofjoints in the rock

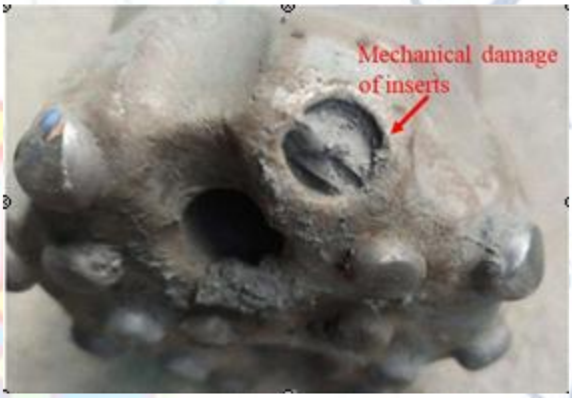

Figure 4: Failed DTH drill bit due to mechanical damage of insert

3.3 Statistical analysis

The basic packages have been used in software R to estimate plots between the variable. The scatter plot for mechanical failure due to inserts, presence of joints in the rock, and failure due to high hardness of strata have been derived from their bench number. Figures 5-7 represent the behavior of drill bit life data with respect to bench number.

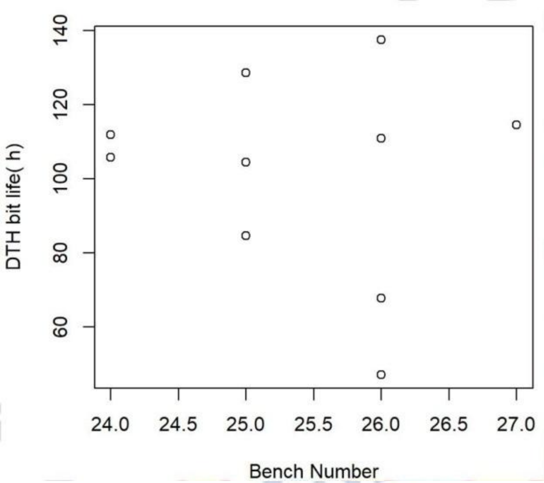

Figure5:DTHbit life in hours due to the hardness of strata.

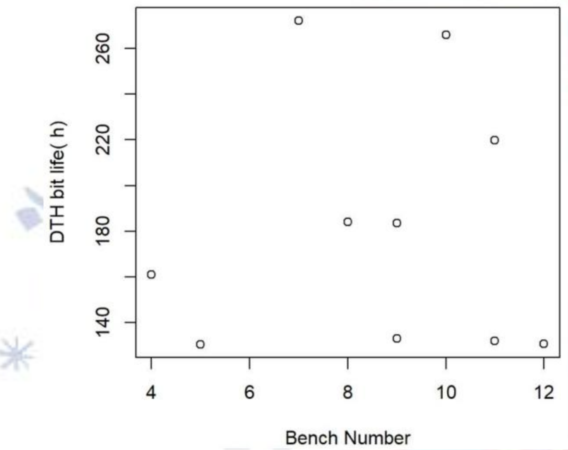

Figure 6: DTH bit life in hours due to mechanical damage of inserts.

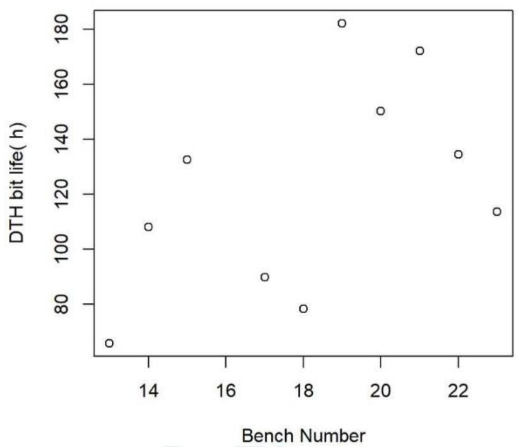

Figure 7: DTH bit life in hours due to the presence of joints in the rock.

In figures 5-7, bit life data distribution does not make any pattern. The easy fit software helps to estimate the distribution model using the goodness of fit test approach. In the study, a number of fitting models have been tried to find the best-fit distribution model for the particular set of data. This software determines the Weibull distribution as the best-fit distribution model for the failure data due to the hardness of strata. Also, the model parameters and the probability density function (PDF) have been computed using the software. The beta distribution was found to be the best-fit distribution model for the failure data due to mechanical damage on insets. Also, the model parameters and the probability density function have been computed using the software. Further, the normal distribution model was found as the best-fit distribution model for the failure data due to the presence of joints in the rock. The software also computed the model parameters and the probability density function. Figures 8-10 depict the probability density function for each case.

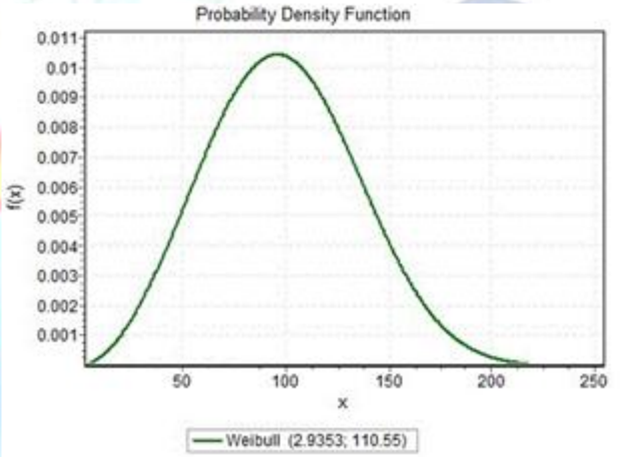

Figure 8: PDF for the failure data due to hardness.

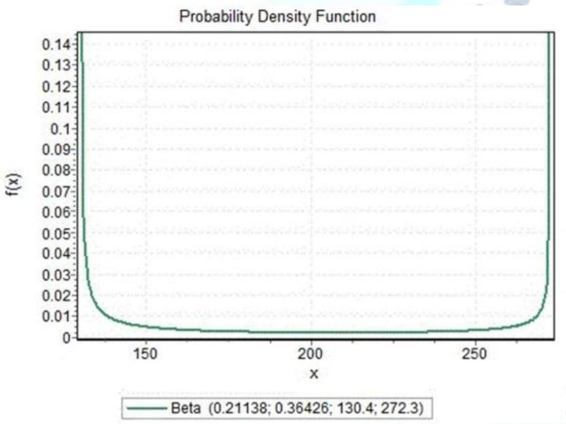

Figure 9: PDF for the failure data due to mechanical damage

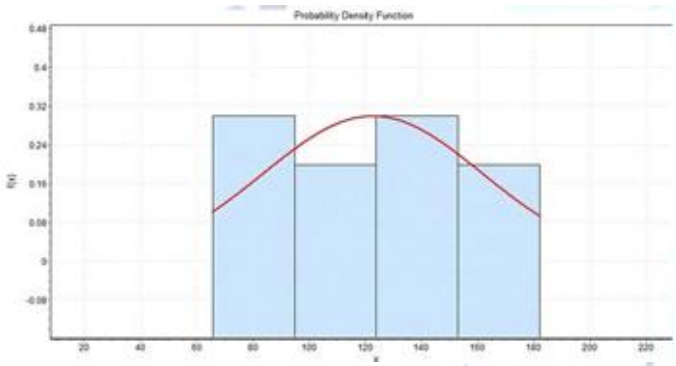

Figure 10: PDF for the failure data due to presence of joints

4. RESULTS

The reliability of drill bit due to their failure modes have been computed based on the probability distribution function. The shape of the probability distribution function depicts the reliability of the bit. The obtained PDF function for failure due to hardness, mechanical damage, and failure due to joints' presence also calculate the distribution parameters. These parameters help to estimate the reliability of bit. This study estimates the reliability of drill bits in three major locations separately. The reliability of DTH bits was found 13% when drilling in ore, and the failure occurred due to the hardness of strata. However, the reliability of DTH bits was found 53% when drilling in white shale. In this case, the failure was observed due to the mechanical damage of buttons. Also, the reliability of DTH bits was found 61% when drilling in black shale. In this case, the failure was noticed due to joints in the rock.

The reliability results were obtained using the software R, considering the probability distribution function. Theresults depict that the failure mode affects the life of a drill bit. Further, the drilling material such as ore, white shale and black shale, play an essential role in the failure of the bit component.

5. CONCLUSION

The present study finds the reason for the failure of the DTH drill bit in Barytes mine with its three major areas of drilling materials. Failure data collection has been done for three particular types of failure modes. The best-fit distribution model has been determined for the dataset, and their corresponding probability distribution function was also derived. The reliability of DTH bits were estimated as 13%, 53%, and 61%, respectively, when drilling in ore, white shale, and black shale. The significance of this study will help engineers to understand the different types of failure modes of DTH bits in barytes mine. Also, it will help to estimate the reliability of DTH bits in a particular location. The reasons for failure can be used for the up-gradation of DTH bits.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Beste, Ulrik. On the nature of cemented carbide wear in rock drilling. Diss. Acta Universitatis Upsaliensis, 2004.

[2] Beste, Ulrik, and Staffan Jacobson. "A new view of the deterioration and wear of WC/Co cemented carbide rock drillbuttons." Wear 264.11-12 (2008): 1129-1141.

[3] Ren, Xiaoyong, Hezhuo Miao, and Zhijian Peng. "A review of cemented carbides for rock drilling: an old but still tough challenge in geo-engineering." International Journal of Refractory Metals and

[4] Larsen-Basse, J. "Wear of hard-metals in rock drilling: asurvey ofthe literature." Powder Metallurgy 16.31 (1973): 1-32.

[5] Prakash, Satya, and A. K. Mukhopadhyay. "Reliability analysis of tricone roller bits with tungsten carbide insert in blasthole drilling." International Journal of Mining, Reclamation and Environment 34.2 (2020): 101-118.

[6] Tkalich, Dmitry, et al. "Wear of cemented tungsten carbide percussive drill–bit inserts: Laboratory and field study." Wear 386 (2017): 106-117.

[7] Karasawa, H., et al. "Methods to estimate the rock strength and tooth wear while drilling with roller-bits—part 2: insert bits." J. Energy Resour. Technol. 124.3 (2002): 133-140.

[8] Thoman, Darrel R., Lee J. Bain, and Charles E. Antler. "Maximum likelihood estimation, exact confidence intervals for reliability, and tolerance limits in the Weibull distribution." Technometrics 12.2 (1970): 363-371.

[9] McGehee, D. Y., et al. "The IADC roller bit dull grading system." IADC/SPE Drilling Conference. OnePetro, 1992.