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Introduction to Hydraulic Excavator Machine and Analysis and Elimination of Arm Bush Failures

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ABSTRACT

A comprehensive overview of hydraulic excavators, focusing on the issue of bush failures in 3-ton excavators and the need for a material change. Hydraulic excavators are introduced as versatile construction equipment used for various applications, including digging, material handling, demolition, and more. Here highlights the importance of addressing bush failures, discussing an 8D report methodology for analysis and resolution. Additionally, it compares metallic and nylon bushes, emphasizing their respective advantages and limitations. This is concludes that a material change is necessary to improve performance and reliability. The validation of the new bush material in field conditions is emphasized as a crucial step to ensure its effectiveness. Overall, this abstract sheds light on the significance of addressing bush failures and underscores the importance of selecting the appropriate material to enhance the longevity and efficiency of 3-ton excavators.

Keywords: Material, Analytical modeling & Hydraulic excavator

1. INTRODUCTION

An excavator is a must on your job site when you need to lift heavy amounts of soil. Excavators are popular earthmoving vehicles that feature a bucket, arm, rotating cab and movable tracks. These components provide superior digging power and mobility, allowing this heavy equipment to perform a variety of functions, from digging trenches and breaking holes to lifting away waste and excavating mines.

I. **Crawler Excavator: -** crawlers run on two large endless tracks and are optimal for mining and heavy-duty construction jobs.

II. **Wheeled Excavator: -** Wheeled excavators are similar in size and appearance to crawlers but run on wheels instead of tracks.

III. **Dragline excavator: -** The dragline excavator is a larger excavator that operates with a different process..

IV. **Suction Excavators**: - Also known as vacuum excavators, suction excavators feature a suction pipe capable of providing up to 400 horsepower.

V. **Skid Steer Excavators: -** Unlike standard excavators, skid steers have booms and buckets that face away from the driver.

VI. **Long Reach Excavators: -** As its name suggests, a long reach excavator features a lengthier arm and boom sections.

VII. **Mini Excavators:-** In recent years, more contractors are using mini excavators, a smaller and lighter version of the standard excavator capable of minimizing ground damage and fitting through crowded, narrow sites like parking lots and indoor spaces.

2. PROBLEM IDENTIFICATION & OBJECTIVES

The main causes of bush inner face and edges wearing in a hydraulic excavator are improper lubrication, contamination, overloading, and poor design. Other factors that can contribute to bush wear include the operating environment and the age of the bushings. If you notice that the bushings in your hydraulic excavator are wearing out, it is important to take action to prevent further damage. By inspecting the bushings regularly, lubricating them properly, and replacing them when they wear out, you can help to extend the life of the bushings and prevent premature wear.

3. DESIGN

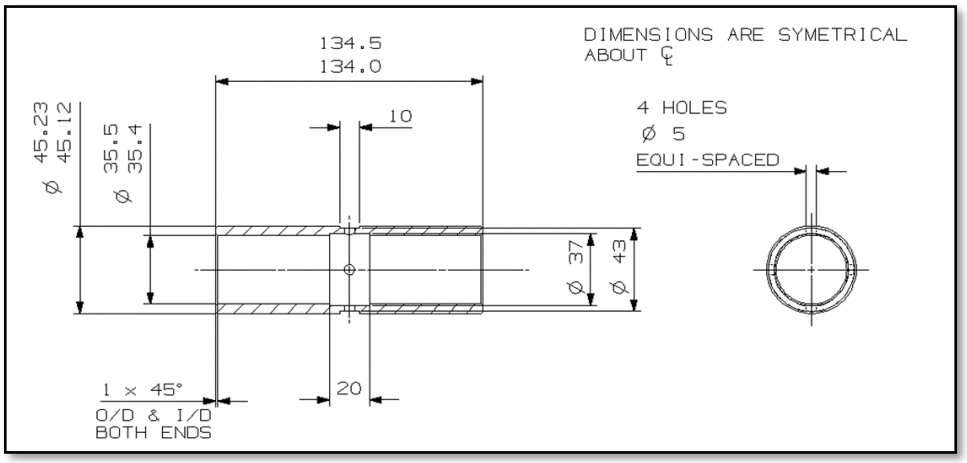

Fig.1 Dimensional Inspection of Bush Stock

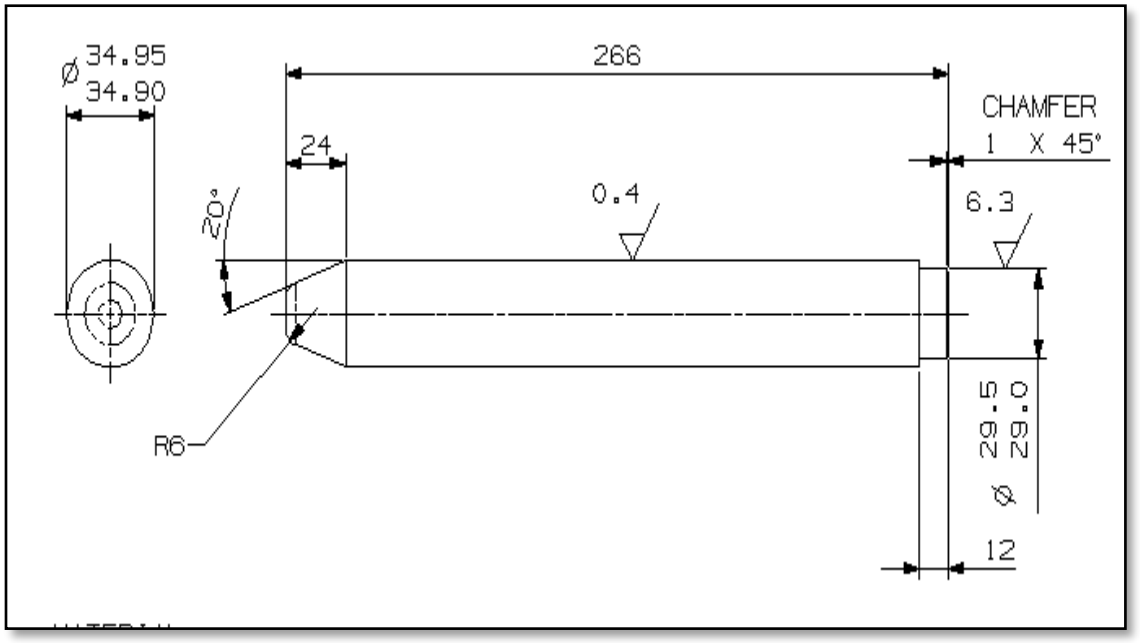

Table 1 Specification with reference to instrument

Parameter	Specification	Instrument used	Actual Measurement Result				
			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Bush ID	35.45 ± 0.05	Bore Gauge	35.44	35.41	35.43	35.44	35.44
Bush OD	45.175 ± 0.055	Bore Gauge	45.20	45.22	45.19	45.22	45.23
Bush Length	134.25 ± 0.25	Digital Vernier	134.2	134.18	134.21	134.21	134.2
Pin OD	34.90-34.95	Micro-meter	34.92	34.90	34.90	34.90	34.92

4. Weibull Analysis or Life Data Analysis

Weibull Analysis is an effective method of determining reliability characteristics and trends of a population using a relatively small sample size of field or laboratory test data.

Life data analysis requires the practitioner to:

- Gather life data for the product.

- Select a lifetime distribution that will fit the data and model the life of the product.
- Estimate the parameters that will fit the distribution to the data.
- Generate plots and results that estimate the life characteristics of the product, such as the reliability or mean life.

Historical time and failure data can be effectively used to identify critical metrics such as the expected life of a product, how long warranty periods should last, and also to identifying the root cause of a device failure such as a design flaw, improper maintenance, or a bad production run.

The formula general Weibull Distribution for three-parameter pdf is given as:

$$f(x) = \frac{\gamma}{\alpha}\left(\frac{(x-\mu)}{\alpha}\right)^{\gamma-1} exp^{(-(\frac{(x-\mu)}{\alpha})^{\gamma})} \quad x \geq \mu; \gamma, \alpha > 0$$

Where,

- γ is the shape parameter, also called as the Weibull slope or the threshold parameter.
- α is the scale parameter, also called the characteristic life parameter.
- μ is the location parameter, also called the waiting time parameter or sometimes the shift parameter.

The standard Weibull distribution is derived, when μ=0 and α =1, the formula is reduced and it becomes

$$f(x) = \gamma x^{\gamma-1} exp^{(-x)^{\gamma}}, x \geq 0; y > 0$$

5. Analysis

Considering analysis results on failed buses and various studies the material change proposed:

Metallic bushes proposed to be replaced by nylon bushes considering below facts:

I. Self-lubricating property

II. Lighter weight

III. Initial cost of implementation

Proposal accepted and trial batch of 50 bushes scheduled to be assembled in machines and put to different applications at various geographical locations.

Fig.2 Nylon Bush Stock

Sample lot of 50 nylon bushes assembled in machines and put to various applications in field.

The monitoring data is as follows:

S. No.	**Model**	**Machine Numbers**	**Location**	**Trial Hours Clocked**	**Working Application**
1	3 Tonn	M3240501	Anjar, Gujarat	4001	Ground work
2	3 Tonn	M3240502	Aurangabad, Maharashtra	4522	Ground Work
3	3 Tonn	M3240503	Sitamau, Madhya Pradesh	3811	Ground Work

4	3 Tonn	M3240504	Khargone, Madhya Pradesh	3823	Material Handling
5	3 Tonn	M3240505	Dhule, Maharashtra	3810	Ground Work
6	3 Tonn	M3240506	Pali, Rajasthan	3850	Ground Work
7	3 Tonn	M3240507	Guntur, Andhra Pradesh	3825	Material Handing
8	3 Tonn	M3240508	Kollegala, Karnataka	3820	Ground Work
9	3 Tonn	M3240509	Tenkasi, Tamil Nadu	3685	Ground Work
10	3 Tonn	M3240510	Wai, Maharashtra	3726	Ground Work
11	3 Tonn	M3240511	Singhana, Madhya Pradesh	3789	Agri Waste Handling
12	3 Tonn	M3240512	Parippally, Kerala	3762	Forestry
13	3 Tonn	M3240513	Hilsa, Bihar	3754	Ground Work
14	3 Tonn	M3240514	Balrampur, Uttar Pradesh	3750	Material Handling
15	3 Tonn	M3240515	Sirpur, Maharashtra	3891	Ground Work
16	3 Tonn	M3240516	Adoor, Kerala	3760	Forestry
17	3 Tonn	M3240517	Chandrapur, Maharashtra	3965	Gardening
18	3 Tonn	M3240518	Jharsuguda, Odisha	4100	Ground Work
19	3 Tonn	M3240519	Kashipur, Uttarakhand	3899	Agri Waste Handling
20	3 Tonn	M3240520	Nagaon, Assam	3893	Gardening
21	3 Tonn	M3240521	Reengus, Rajasthan	3784	Material Handing
22	3 Tonn	M3240522	Barnala, Punjab	3723	Agri Waste Handling
23	3 Tonn	M3240523	Jind, Haryana	3777	Agri Waste Handling
24	3 Tonn	M3240524	Kaithal, Haryana	3227	Garbage handling
25	3 Tonn	M3240525	Tonk, Rajasthan	2986	Ground Work

The above post improvement tracking data reveals that the nylon bush assembly put to operation in various machines working at different locations and diverse applications has given better performance as compared to the previous metal bushes.

6. RESULT

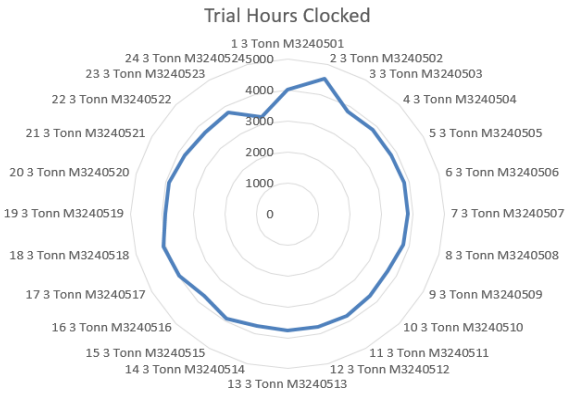

Fig.3 performance as compared to the previous metal bushes.

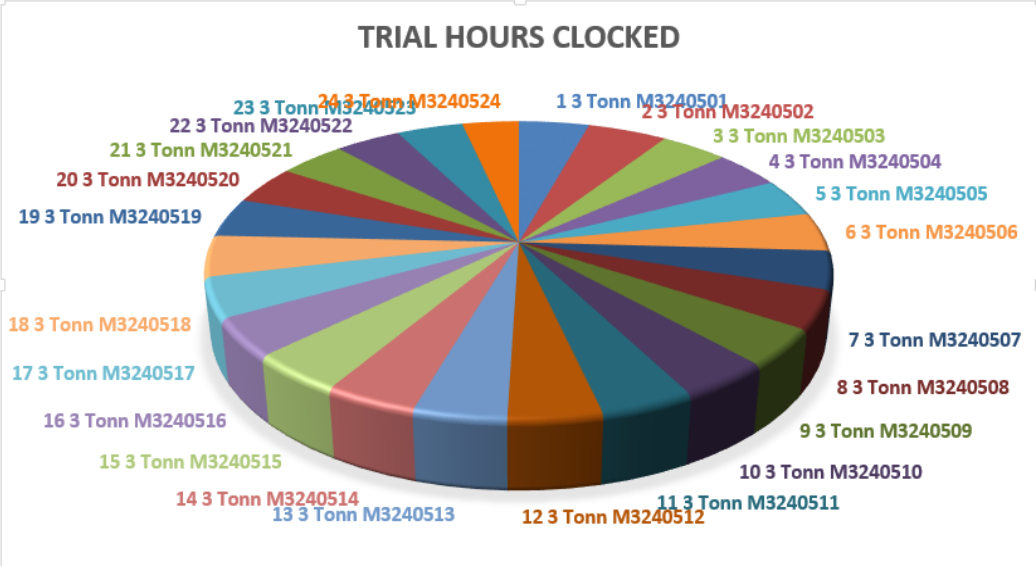

Fig. 4 performance the previous metal bushes

- The average trial hours clocked per machine is 3,771.
- The maximum trial hours clocked per machine is 4,522, for machine M3240502.
- The minimum trial hours clocked per machine is 3,227, for machine M3240524.
- The standard deviation of the trial hours clocked is 245.

The average trial hours clocked per machine is 3,771, which means that most machines have been used for a similar amount of time. However, there is a significant range in the amount of time that the machines have been used, with some machines being used much more than others. The maximum trial hours clocked per machine is 4,522, for machine M3240502, which means that this machine has been used for significantly more time than the average machine. The minimum trial hours clocked per machine is 3,227, for machine M3240524, which means that this machine has been used for significantly less time than the average machine.

The standard deviation of the trial hours clocked is 245, which means that there is a significant amount of variation in the amount of time that the machines have been used. This suggests that some factors, such as the location of the machine or the type of work that it is used for, may have a significant impact on the amount of time that the machine is used.

Overall, the results of the table suggest that the machines have been used for a variety of amounts of time. There is a significant range in the amount of time that the machines have been used, and some factors may have a significant impact on the amount of time that a machine is used.

7. CONCLUSION

Nylon bushings have a number of advantages over metallic bushings, including:

- Reduced initial cost: Nylon is a less expensive material than metal, so nylon bushings are typically less expensive to purchase.
- Delayed greasing requirement timing and reduced greasing frequency: Nylon bushings are self-lubricating, so they do not require as much grease as metallic bushings. This can save time and money on greasing maintenance.
- Corrosion free: Nylon is resistant to corrosion, so it can be used in applications where metallic bushings would corrode.
- Reduced weight: Nylon is a lightweight material, so nylon bushings can reduce the overall weight of a machine.
- Reduced Failure rate and thus reduced warranty cost: Nylon bushings are less likely to fail than metallic bushings, so they can help to reduce warranty costs.
- Reduced maintenance cost: Nylon bushings are easier to maintain than metallic bushings, so they can help to reduce maintenance costs.

Overall, nylon bushings offer a number of advantages over metallic bushings, including reduced initial cost, reduced greasing requirements, corrosion resistance, and reduced weight, reduced failure rate, and reduced maintenance cost.

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