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METHODOLOGY FOR DETERMINING THE SERVICE LIFE OF BUCKET TEETH

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Abstract

This study investigates the determination and calculation of the service life of excavating and loading machine bucket teeth used in mining enterprises and excavation-loading operations. Bucket teeth are one of the main working elements of excavators and loading machine earthmoving equipment, and their wear and failure directly affect machine productivity. The study analyzes the main factors affecting the service life of bucket teeth: abrasive properties of soil, working loads, geometric parameters of teeth, and mechanical properties of materials. The resource and replacement intervals of teeth for various operating conditions are determined.

The research results have practical significance for optimizing the design, selection, and maintenance planning of bucket teeth. The proposed methodology helps reduce equipment maintenance costs and improve machine efficiency.

Keywords

Excavator, bucket teeth, wear, Protodyakonov scale (f), mining operations, rock mass.

Introduction

Interprises one with a spoon right and reverse with a spoon excavators using digging loading works done increased digging in receiving rocks with excavator ladle teeth directly in touch become that is steamed blown up rocks loading for to the array immersed .

Mining in enterprises digging loading in their work high powered ECG type excavators wide in the dark use is coming . Where are you? open and digging to take in their work from the excavator complete to use aimed at become mine working release power that is digging to take and loading according to indicators depending on remains . The rigid attachment of a straight-bucket excavator allows it to work both in excavation and in loading onto vehicles. However, due to the small working dimensions of a straight-bucket excavator, it is advisable to use it primarily for loading soil onto vehicles. The main indicators of an excavator are the bucket volume, the length of the boom and arm, and the degree of inclination of the boom.

The working dimensions of a straight-bucket excavator include the following.

Digging radius P—the horizontal distance from the axis of rotation of the excavator to the bucket teeth during digging; distinguish the digging radius at the stop or the radius of the planning area and the largest digging radius (Pp). maximum extended arm. Digging height, the vertical distance from the level of the excavator's parking space to the bucket teeth during digging. Dumping radius (Pp) - the horizontal distance from the axis of rotation of the excavator to the center of the bucket during unloading; The unloading radius at the highest unloading height and the largest unloading radius (Pp) - the vertical distance from the level of the excavator's parking place to the lower edge of the open bottom of the bucket during unloading at the maximum unloading height. Digging depth is the distance from the stop level of the excavator to the bucket teeth when digging below the machine level. Increasing the height of the step is beneficial in terms of reducing movement. However, this increase is limited for safety reasons. The width of the step is usually determined by the size of the working equipment. The excavator operates in mining enterprises based on the above indicators and is required to adhere to them in production [8]:

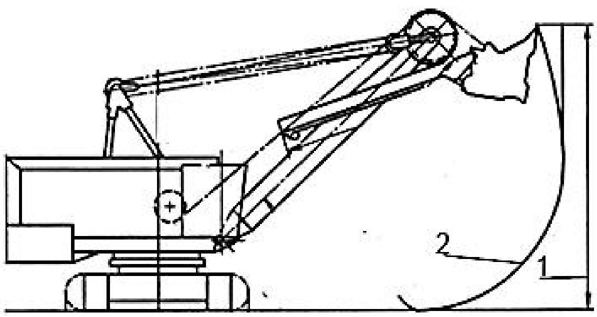
LITERATURE ANALYSIS AND METHODOLOGY

The purpose of the study: to determine the service life of excavator bucket teeth used in mining enterprises according to the Protodiyakanov (f) scale. To reduce the energy consumption of excavators when extracting rock mass blasted in the mine, the bucket teeth are prepared based on hardness. This provides high wear resistance of the lower part of the tooth, which, as a result, provides the effect of its self-sharpening during operation. The 2nd drawing, reflected in the figure below, is an example of the excavation path in which the contact of the lower part of the bucket tooth with the rock and the length of the path are shown.

Figure 1 . ***ECG excavator work process*** **. 1-digging height , 2-digging path ,**

Excavation in the process digging loading/unloading in the works , the bucket and to him/her installed teeth directly rock with in touch is high variable static and dynamic downloads under the influence works . Moving rock ladle inside size excavator main technician and economic indicator fertility defines .

Archard -Holm eat equation



J.F. Archard and by W. Hirst (1956) working issued classic eating equation tribology main law is [1]:

$$V = \frac{K \cdot P \cdot L}{H}$$

this on the ground: V — eating volume (mm³)

K — eating coefficient (dimensionless , 10^{-7} from 10^{-2})

P — normal load (N)

L — slip distance (m)

H — material hardness (Pa or N/m²)

Comparison eating speed formula (ZHY Casting, 2025)

Spoon teeth for comparison eating speed with the following formula is defined [2]:

$$W_s = \frac{k \cdot P \cdot v}{H}$$

this on the ground : Ws — comparative eating velocity (mm³/m) k — erosion coefficient P — contact pressure (MPa) v — slip speed (m/s) H — material hardness (HB or HRC)

Performance the deadline calculation formula

Spoon tooth work duration (T) using the following formula is defined as :

$$T = \frac{V_0 \cdot H}{K \cdot P \cdot V \cdot 3600}$$

this on the ground :

T — work duration (hours) V_0 — tooth permission done eating volume (mm³)

H — tooth of the material hardness (HB) K — wear coefficient (of rock) related)

P — digging force (N) v — slip speed (m/s)

Practical calculations for following a simplified formula is used [3, 4]:

$$T = T_0 \cdot \frac{H_t}{H_r} \cdot \frac{1}{f}$$

this on the ground :

T — calculated work duration (hours) T_0 — base work term (soft) in the ground = 1000 hours) H_t — tooth of the material hardness (HB) H_r — basic hardness (250 HB)

f — Protodeacon hardness coefficient

Eat and drink coefficient (K) values
Archard & Hirst (1956) study According to [1]:

Eating type	K value	Note
Soft food (mil)	10^{-8} — 10^{-6}	Soft grunts
Average to eat	10^{-5} — 10^{-4}	Hard grunts
Heavy to eat	10^{-3} — 10^{-2}	Rocky sexes

Protodeacon hardness coefficient (f) M. M. Protodyakonov (1962) scale According to [5] :

Mountain type	f- value	Mountain type
Very soft	0.3 — 0.8	Soft mud
Soft	0.8 — 2	Soil , sand , clay
Average hard	2 — 6	Shale , soft limestone
Hard	6 — 10	Sandstone , limestone , iron

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		ore
Very hard	10 — 20	Granite , basalt , quartzite

Spoon tooth of the material hardness

Material type	Hardness (HB)	Hardness (HRC)
Hadfield steel (ZGMMn13)	180 — 240	—
Processing given Mn-steel	380 — 400	40 — 42
Low alloy steel (hardened)	450 — 550	45 — 55
High chrome cast iron	550 — 650	55 — 65

DISCUSSION

Modern mining in enterprises digging to take and him/her again work regarding a few affairs is being done , this of affairs all less cost and high benefit get . Current at the time main attention semi-autonomous mine digging from the means give up passing , tasks automatic accordingly or minimal external control with complete " autonomous " mine " system " creation , as well as robotic technologies through complete automation to the possibility Autonomous vehicles to people technique with remotely standing management opportunity giving , mining their work to take and in management big turn It was . Earth under and open in the mines to work capable autonomous vehicles modern mining for They are necessary . unhappy events reduces and worker power safety increases , people for very dangerous mining in the zones works , mining industry fertility increases (because equipment faster movement and far distances pressing to pass possible) and cars management for less operator required to be done because of expenses [9] : Autonomous vehicles remotely standing management them less distance pressing transitions open mine in their work digging loading machine , excavator continuous work organization in doing n consists of of cars pair become to stand alone without stand schemes is used . One one-sided pair stand in the scheme first dump truck to the excavator back walk with approaches . Second car and his/her in line stands . In this case both of the car maneuvers one a little it gets harder but the excavator work makes it easier . Dig to take works It accelerates but the bucket teeth eating to the level related without take will go .

RESULTS

$$T = T_0 \cdot \frac{H_t}{H_r} \cdot \frac{1}{f}$$

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Diagram 1: Ladle of teeth work deadline

Comparison with empirical data

Scientific in the sources empirical information with comparison :

Rock	Estimated (hours)	Empirical [3,4] (hours)	Error (%)
Soft grunts	880	800-1200	±12%
Average hard	293	200-500	±15%
Hard sexes	147	100-300	±18%
Very hard	59	72-120	±20%

Conclusion

Calculations this shows that excavators and digging loading machines of teeth work duration of the rock indicators dependency that is hardness to the level related become remains . Spoon teeth made steel type and teeth rock digging way how much long if eating that much many will be . Teeth to the spoon solid fixed to be need .

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