Performance Analysis of Front-Mounted and Rear-Mounted Cutter Housings for Atmospheric Pressure Cutterhead Shield Machines in Hard Rock Formations: Postprint

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Abstract

With the widespread application of shield tunneling technology in complex hard rock formations, the impact of cutter housing assembly configurations in atmospheric pressure cutterhead shield machines on construction efficiency and safety has become increasingly prominent. This paper investigates the Guangzhou Haizhuwan Tunnel Project and systematically compares and analyzes the application differences between front-loading cutter housings (C-block mechanical self-locking structure) and rear-loading cutter housings (multi-stage bolted connection structure) in terms of abnormal failure modes, cutter replacement efficiency, and service life, under geological conditions featuring argillaceous siltstone with uniaxial compressive strength reaching 101 MPa. The research reveals that front-loading cutter housings effectively disperse dynamic rock-breaking loads through integrated structural design, significantly reducing abnormal failure rates during hard rock excavation, with no occurrence of systematic failures such as lock detachment or bolt fracture. The assembly process demonstrates high visual clarity, achieving a 38%-54% improvement in cutter replacement efficiency compared to rear-loading configurations. Actual project data indicate that front-loading cutters exhibit an average service life extension of approximately 50%, which, combined with mechanical self-locking characteristics, can form a positive cycle effect of "high efficiency-low risk," increasing daily excavation progress by 65% in hard rock sections and achieving a 44% monthly progress improvement in upper-soft lower-hard strata. By contrast, rear-loading cutter housings constitute a weak link in hard rock construction due to reliability deficiencies in the bolted connection system under high-frequency vibration. The research conclusions demonstrate that front-loading cutter housings should be prioritized in hard rock strata to enhance construction stability and economic efficiency, while rear-loading cutter housings require anti-vibration im-

provements to meet the demands of composite formations. This study provides practical basis and technical paradigm for cutter system selection in atmospheric pressure cutterhead shield machines operating in complex rock strata.

Full Text

Analysis of Application Performance of Front-Mounted and Rear-Mounted Disc Cutters on Shield Machines in Hard Rock Formations

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Abstract

As shield tunneling technology becomes widely applied in complex hard rock formations, the cutter installation configuration of atmospheric pressure face shield machines has an increasingly significant impact on construction efficiency and safety. This study takes the Guangzhou Haijinwan Tunnel project as its research subject, systematically comparing and analyzing the application differences between front-mounted cutter holders (C-block mechanical self-locking structure) and rear-mounted cutter holders (multi-level bolt connection structure) in terms of abnormal damage patterns, cutter replacement efficiency, and service life, considering ground conditions of argillaceous siltstone with uniaxial compressive strength reaching 101 MPa.

The research findings indicate that front-mounted cutter holders effectively distribute dynamic rock-breaking loads through integrated structural design, significantly reducing abnormal damage rates during hard rock excavation, with no systematic failures such as lock detachment or bolt fracture. Their assembly process features high visibility, improving cutter replacement efficiency by approximately 38%-54% compared to rear-mounted types. Actual project data demonstrates that front-mounted cutters achieve an average service life extension of approximately 50%. Combined with the mechanical self-locking characteristic, this creates a positive cycle effect of "high efficiency-low risk," increasing daily excavation progress by 65% in hard rock sections and monthly progress by 44% in upper-soft lower-hard strata.

In contrast, rear-mounted cutter holders become a weak link in hard rock construction due to reliability defects in the bolt connection system under high-frequency vibration. The research conclusions indicate that front-mounted cutter holders should be prioritized in hard rock formations to enhance construction stability and economy, while rear-mounted cutter holders require anti-vibration improvements to meet the demands of composite strata. This study provides practical basis and technical paradigms for cutter system selection in atmospheric pressure face shield machines operating in complex rock formations.

Keywords: front-mounted cutter holder; rear-mounted cutter holder; hard rock formation; abnormal damage; service cycles; comparative analysis

Note: Figure translations are in progress. See original paper for figures.