

ABSTRACT

The front brake system of an Off-Highway Truck is a critical component that plays an essential role in ensuring operational safety and efficiency in mining activities. The high frequency of failures in this system leads to increased downtime, maintenance costs, and reduced equipment productivity. This study aims to identify the types and failure patterns of the front brake system, analyze the root causes of failures using Fault Tree Analysis (FTA), and assess the failure risk levels using Failure Mode and Effects Analysis (FMEA). This study utilized historical Daily Maintenance Breakdown (DMBD) data from eight Off-Highway Trucks collected between January and November 2025. The analysis employed Pareto analysis, Control Charts, and the Weibull distribution to identify dominant failure modes and failure patterns. Furthermore, FTA and FMEA were applied to determine the root causes of failures and establish maintenance priorities based on failure risk. The results indicate that brake dragging, brake fluid leak, brake error, and brake hose leak were the most dominant failure modes in the front brake system. The Weibull distribution analysis showed that most failure modes had a shape parameter (β) of less than 1, indicating an infant mortality failure pattern, suggesting that failures were primarily influenced by maintenance practices and operating conditions rather than component aging. The FTA results revealed that the failures resulted from a combination of component condition, maintenance quality, and operational factors. Meanwhile, the FMEA results indicated varying risk levels among the identified failure modes, providing a basis for prioritizing corrective actions.

Keywords: *front brake, Off-Highway Truck, Weibull distribution, Fault Tree Analysis, Failure Mode and Effects Analysis.*

INTISARI

Sistem *front brake* pada Off-Highway Truck merupakan komponen kritis yang berperan dalam keselamatan dan kelancaran operasi pertambangan. Tingginya frekuensi kerusakan pada sistem ini menyebabkan peningkatan *downtime*, biaya perawatan, dan penurunan produktivitas unit. Penelitian ini bertujuan mengidentifikasi jenis dan pola kerusakan *front brake*, menganalisis akar penyebab kerusakan menggunakan *Fault Tree Analysis (FTA)*, serta menentukan tingkat risiko kegagalan menggunakan *Failure Mode and Effect Analysis (FMEA)*. Penelitian menggunakan data historis *Daily Maintenance Breakdown (DMBD)* delapan unit Off-Highway Truck periode Januari–November 2025. Analisis dilakukan dengan metode Pareto, *Control Chart*, dan distribusi Weibull untuk menentukan kerusakan dominan dan pola kegagalan, kemudian dilanjutkan menggunakan *FTA* dan *FMEA* untuk mengidentifikasi akar penyebab serta menentukan prioritas risiko kegagalan. Hasil penelitian menunjukkan bahwa *brake* lengket, *brake fluid leak*, *error brake*, dan *hose brake leak* merupakan kerusakan yang paling dominan pada sistem front brake. Analisis distribusi Weibull menunjukkan sebagian besar mode kegagalan memiliki nilai *shape parameter* (β) < 1 , yang mengindikasikan pola *infant mortality*, sehingga kegagalan lebih dipengaruhi oleh faktor *maintenance* dan pengoperasian dibandingkan umur pakai komponen. Analisis *FTA* menunjukkan bahwa kerusakan terjadi akibat kombinasi faktor kondisi komponen, kualitas *maintenance*, dan pengoperasian unit. Sementara itu, hasil *FMEA* menunjukkan adanya perbedaan tingkat risiko pada setiap mode kegagalan sehingga dapat digunakan sebagai dasar penentuan prioritas perbaikan.

Kata kunci: *front brake*, Off-highway truck, distribusi Weibull, *Fault Tree Analysis*, *Failure Mode and Effect Analysis*.