

TESIS

**ANALISIS *FATIGUE* PADA OPERATOR *DUMP TRUCK* DI INDUSTRI
PERTAMBANGAN BATUBARA DENGAN PENDEKATAN *MACHINE LEARNING*
BERBASIS *SMARTWATCH***

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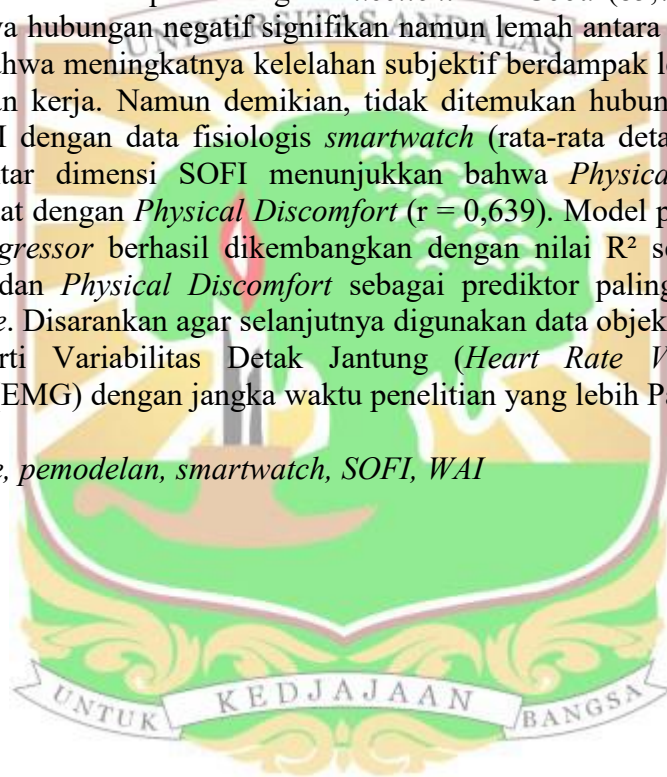
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DEPARTEMEN TEKNIK LINGKUNGAN
FAKULTAS TEKNIK
UNIVERSITAS ANDALAS**

2026

ABSTRAK

Kelelahan (*fatigue*) merupakan salah satu faktor utama penyebab kecelakaan kerja pada operator *dump truck* di industri pertambangan. Penelitian ini bertujuan untuk menganalisis tingkat *fatigue* dan kemampuan kerja operator, hubungan antara kelelahan subjektif dan kemampuan kerja, serta keterkaitannya dengan data objektif fisiologis yang direkam menggunakan *smartwatch*, sekaligus mengembangkan model prediksi *fatigue* berbasis *machine learning*. Penelitian dilakukan pada 276 operator *dump truck* di PT Pama Persada Nusantara Site MTBU dengan menggunakan instrumen *Swedish Occupational Fatigue Inventory* (SOFI), *Work Ability Index* (WAI), dan data objektif *smartwatch* (durasi tidur dan detak jantung). Hasil penelitian menunjukkan bahwa tingkat kelelahan subjektif mayoritas berada pada kategori ringan, namun dimensi *Lack of Energy* menunjukkan tingkat kelelahan sedang pada 45% operator, menjadikannya dimensi paling rentan. Sebaliknya, kemampuan kerja (WAI) mayoritas berada pada kategori *Excellent* dan *Good* (85,7%). Analisis korelasi menunjukkan adanya hubungan negatif signifikan namun lemah antara SOFI dan WAI, yang mengindikasikan bahwa meningkatnya kelelahan subjektif berdampak lemah pada penurunan persepsi kemampuan kerja. Namun demikian, tidak ditemukan hubungan signifikan antara SOFI maupun WAI dengan data fisiologis *smartwatch* (rata-rata detak jantung dan durasi tidur). Analisis antar dimensi SOFI menunjukkan bahwa *Physical Exertion* memiliki hubungan paling kuat dengan *Physical Discomfort* ($r = 0,639$). Model prediksi menggunakan *Random Forest Regressor* berhasil dikembangkan dengan nilai R^2 sebesar 0,408, dengan *Physical Exertion* dan *Physical Discomfort* sebagai prediktor paling berpengaruh dalam memodelkan *fatigue*. Disarankan agar selanjutnya digunakan data objektif yang lebih canggih dan sensitif, seperti Variabilitas Detak Jantung (*Heart Rate Variability/HRV*) atau *Electromyography* (EMG) dengan jangka waktu penelitian yang lebih Panjang.

Kata kunci: *fatigue, pemodelan, smartwatch, SOFI, WAI*



ABSTRACT

Fatigue is one of the primary contributing factors to occupational accidents among dump truck operators in the mining industry. This study aims to analyze the level of fatigue and work ability of operators, examine the relationship between subjective fatigue and work ability, and investigate their associations with physiological data recorded using a smartwatch, as well as to develop a machine learning-based fatigue prediction model. The study was conducted among 276 dump truck operators at PT Pama Persada Nusantara, MTBU Site, using the Swedish Occupational Fatigue Inventory (SOFI), the Work Ability Index (WAI), and objective smartwatch data, including sleep duration and heart rate. The results indicate that the majority of operators experienced subjective fatigue at a mild level; however, the Lack of Energy dimension showed a moderate level of fatigue in 45% of operators, making it the most vulnerable dimension. In contrast, most operators demonstrated high work ability, with 85.7% classified in the Excellent and Good categories based on the WAI. Correlation analysis revealed a significant but weak negative relationship between SOFI and WAI, suggesting that increased subjective fatigue is associated with a decline in perceived work ability. Nevertheless, no significant associations were found between either SOFI or WAI and physiological smartwatch data, including average heart rate and sleep duration. Inter-dimension analysis of SOFI showed that Physical Exertion had the strongest correlation with Physical Discomfort ($r = 0.639$). A fatigue prediction model developed using a Random Forest Regressor achieved an R^2 value of 0.408, with Physical Exertion and Physical Discomfort identified as the most influential predictors in modeling fatigue. Future studies are recommended to employ more advanced and sensitive objective measures, such as Heart Rate Variability (HRV) or Electromyography (EMG), along with longer observation periods.

Keywords: *fatigue, modeling, smartwatch, SOFI, WAI*

