Enhancing Safety through Driver Fatigue Monitoring System (DFMS) at Khondbond Iron & Mn. Mine, Tata Steel Limited

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1. Abstract:

This technical paper explores the comprehensive deployment of the Driver Fatigue Monitoring System (DFMS) at Tata Steel's Khondbond Iron & Mn. Mine. It presents an analysis of the mining sector's complexities, the challenges associated with driver fatigue, and the careful execution of DFMS as a pivotal solution. The paper examines the critical issues, the innovative technology behind DFMS, the intricacies of implementation, and the remarkable benefits realized. This paper demonstrates how cutting-edge technology can significantly enhance safety protocols and operational efficiency in high-risk industrial settings.

2. Introduction:

Mining operations involving Heavy Earth Moving Machinery (HEMMs) are inherently complex and demanding. With the expansion of operations and increased fleet size, ensuring the safety of operators has become a paramount concern. This section introduces the pressing need for advanced monitoring systems and outlines the objectives of implementing DFMS.

Several historical accidents have occurred related to driver fatigue in mining operations. Statistics, case studies, and incidents are required to be analysed to understand the gravity of the issue. Regulatory frameworks and safety standards set by DGMS (Tech) are explored, emphasizing the need for compliance and the importance of proactive safety measures.

3. Current Issue or Problem:

The paper explores the specific challenges faced by Khondbond Iron Mine of Tata Steel Limited, such as the vast operational area, diverse fleet, and the constant risk of accidents due to driver fatigue. Real-life incidents and their impact on both personnel and equipment. The financial implications of downtime and accidents are analysed, underlining the urgency for a robust solution.

In the fast-paced and highly productive environment of any opencast Iron ore mine, ensuring the safety of our Heavy Earth Moving Machinery (HEMMs) & Light Vehicle drivers is our prime motive. With increase in fleet size & utilization of HEMMs and extensive driving routes have made it challenging to mitigate the potential risks associated with driver fatigue.

Although Various DGMS Circulars have been issued by the Director from time to time for safe HEMMs & other vehicle operations with reference to provisioning and satisfactory working of various safety features, but driver fatigue continues to be a major cause of safety concern. So DGMS (Tech) circular No. 06 of 2020 in respect of the minimum required design/functionality of DFMS and other safety features was issued as stated below.

DGMS (Tech) circular No. 06 of 2020:

Enclosure to DGMS (Tech) Circular No. of 2020 guidelines in respect of provisioning of safety features of HEMMs & Heavy/Light Vehicles for safe deployment in opencast mines.

a) Warning System for Operator Fatigue:

A system capable of analysing various symptoms associated with Operator fatigue to detect drowsiness of Operator from regular driving/ operating behaviour and sound loud audio and visual warnings immediately upon detection of drowsiness to a left the Operator and others in the vicinity by incorporating one or more technique(s).

The Warning System for Operator Fatigue shall meet the following minimum requirements and standards:

1. The system shall boot automatically along with starting of Engine.
2. The system shall detect state of drowsiness of Operator from regular driving behaviour and shall provide loud verbal warnings.
3. The system shall have following four stages:
    a) Initialization
    b) Tracking
    c) Drowsiness Detection
    d) Warning
4. Components of the system shall in no way obstruct Operator's line of sight hindering.
5. The System may be provided with provisions for 96 hours recording the warning generated with time stamp.
6. For determining type, duration and sound level of audio warning and intensity of external Visual warning.

Fig: Snap of Driver sleeping while driving

4. Analysis:

The human factors contributing to driver fatigue were analysed. The psychological, physical, and environmental aspects affecting operator alertness were explored. The paper delves into existing safety measures, highlighting their limitations and emphasizing the need for a more sophisticated and proactive approach in real time basis.

5. Solution Adopted:

DFMS is introduced as a ground-breaking solution to tackle driver fatigue effectively. The technology, including cameras, processors, and advanced algorithms, is explained in detail. The system's ability to monitor operator behaviour, detect signs of fatigue, and trigger timely alerts is elaborated upon. The integration of DFMS with existing safety protocols is discussed, showcasing the synergy between cutting-edge technology and established safety practices.

DFMS system has been installed to mitigate driver fatigue within our Departmental & contractual fleet. This system will utilize cutting-edge technology to track driver behavior, phycological indicators and external conditions to provide timely alerts and interventions, ultimately improving safety, reducing accidents, and enhancing operational efficiency.

6. Technical Details:

6.1. Main Unit:

Item	Description
Main Processor	ARM Cortex A7 Quad
Sub Processor	ARM Cortex M0(for illusion & Camera Control)
Camera	Effective Pixels (720 X 480)
View Angle (Camera)	$42°(D)$ $30°(H)$ $42°(V)$
Video (Video Out)	CVBS 1Vp-p 75Ω

6.2. Hardware:

Main unit	Power cable 3P	PCI Box
		
Micro SD card (Consumable)	**Contactless CAN Reader (Optional)**	**FMS Cable (RS-232) (Optional)**
		

6.3. LED Warning System:

Features	Features	Level (Seconds)			LED 2 (Blinking)
		3	2	1	
Drowsiness	When the driver closes eyes for certain period	1.5	2	2.5	
	If the driver closes eyes again within 30 seconds	–			&
Distraction	When the driver looks outside of warning range below	3	4	5	
	If the driver remains distracted for certain period	5	6	7	&
Yawning	When the driver yawns for 3 seconds twice within 1 minute	3			
Phone use	When the driver talks over the phone for certain period (Every 30 seconds)	2	3	4	
Smoking	When the driver smokes for certain period				

6.4. Parameters of Warning:

Type of warning	Level 3		Level 2 (Default)		Level 1	
	Time	Angle	Time	Angle	Time	Angle
Drowsiness	1.5S	Left : 25° Right : 25° Top : None Down : 15°	2S	Left : 30° Right : 30° Top : None Down : 20°	2.5S	Left : 35° Right : 35° Top : None Down : 25°
Distraction	3S Extra warning: 5S		4S Extra warning: 6S		5S Extra warning: 7S	
Phone	2S		3S		4S	
Smoking						
Yawning	3S		3S		3S	

6.5. Checkpoints to identify whether DFMS Camera is working or not on-site?

Checkpoints
From the Fig, we can observe 3 lights representing 3 different Indications.
Red - Power Supply, turns ON immediately after Engine ON and then turns OFF.
Green - GPS Tracking, turns ON immediately after Engine ON and then turns OFF.
Blue - GSM Signal, keeps blinking until the Engine turns OFF.
Checkpoint 2
When the Engine turned ON, we need to hear "Trip Started"

Fig:Right Setup of DFMS looks like.

6.6. Error Description:

Error Description	LED Color		Possible Cause
Camera Error		LED 1: Yellow LED 2: Red	Camera component error
GPS Error		LED 1: Yellow LED 2: Blue	GPS component error
Other problems		LED 1: Yellow LED 2: Green	SD Card or Video recording error CAN communication error

6.7. Main Functions of DFMS:

i) Operator Alert

ii) Tracking System

Communication with Authorized Person: Simultaneously, the system can send messages to authorized individuals or parties. This can be done through various communication methods, such as SMS, email, or app notifications. The message sent to the authorized person includes details about the driver's condition, such as the driver's location, vehicle information, the behavior patterns that triggered the alert, and the time of the incident.

iii) Alert Details & Monitoring

The Alerts is also sent to Online DFMS fleet dashboard where all alerts can be reviewed & analyzed.

We have set up a command center to monitor live events & to communicate instantly to fatigued operators thru two-way communication system installed in vehicles & command center.

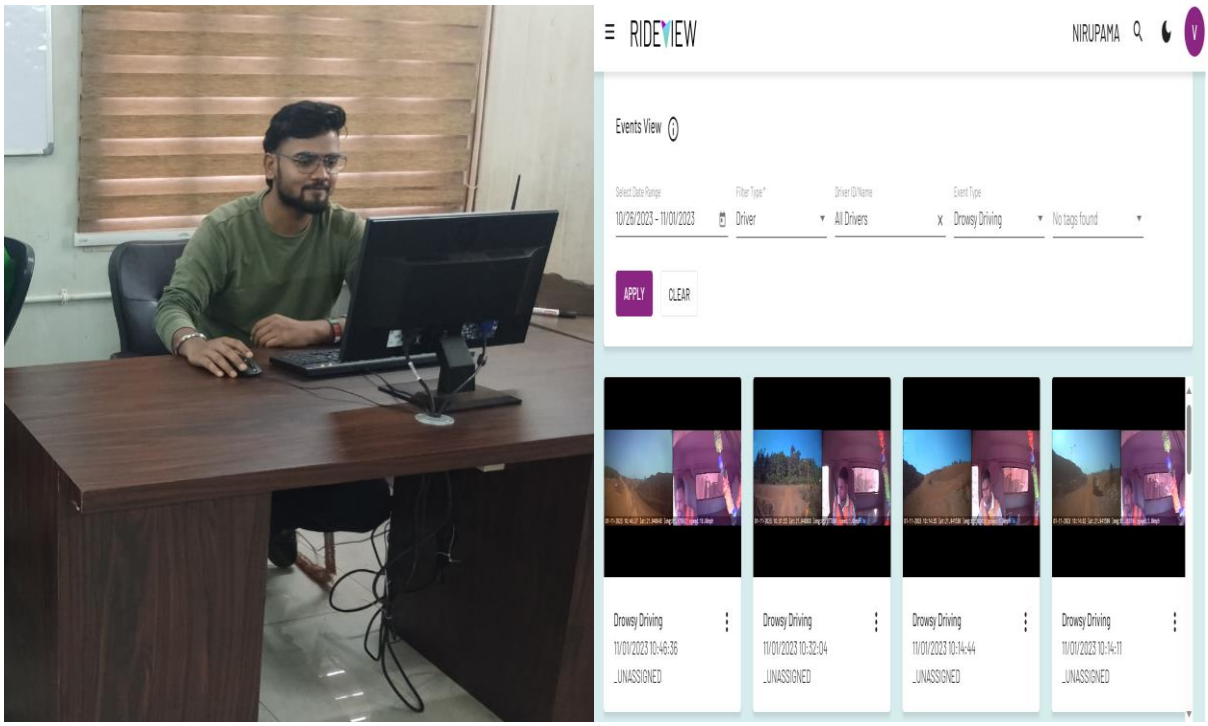

Fig: Online DFMS control Room at Khondbond Iron & Mn. Mine

iv) Workflow of DFMS:

1.Data Collection

(The camera captures face, eyelid, neck, hand movements
Drowsiness- Eyes Closed for 1.5 Sec or accumulated time of closed eyes exceed 6 seconds within 60-second interval.**)**

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2.Data Analysis

(Image collected like closed eyelids is used to analyze drivers' behavior thru different algorithms)

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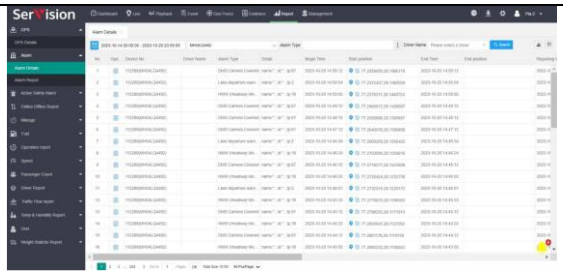
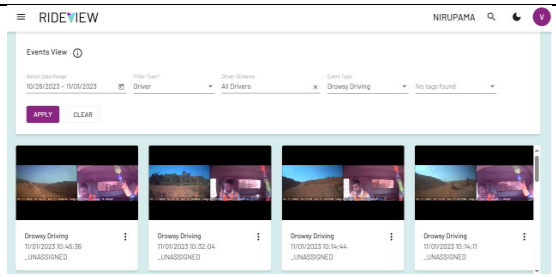
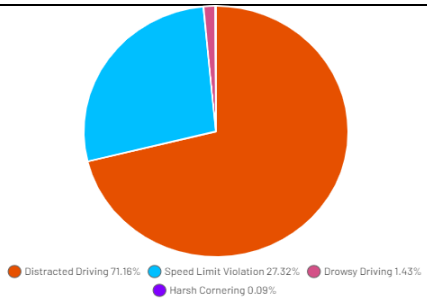
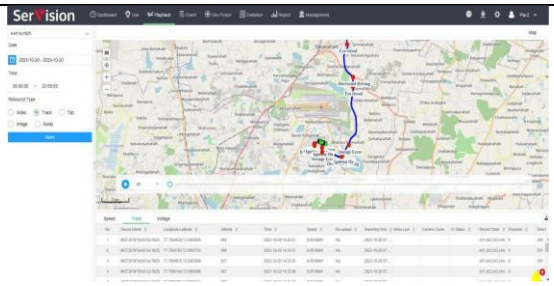
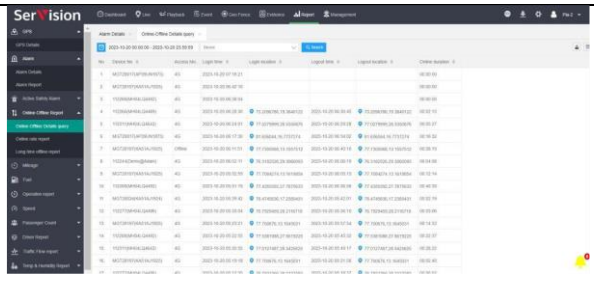
3.Alerts and Interventions

(When the system detects signs of driver fatigue. It triggers alerts.)

v) Features of Online DFMS fleet dashboard:

Features	Description
Live information of Safety Alarm.	
Auto Upload of alert video & image recording with remote obtainment (Viewing and playback of history footages) thru App/Weblink.	
Dangerous driving behavior alert analysis (Operator, Machine, Location, Type of alert wise).	
Remote video surveillance and GPS-based positioning and tracking	
Device malfunction, tampered, online & offline report.	

7. Implementation Process:

The implementation process covers vendor selection, system customization, training modules designed for operators and staff, and the integration of DFMS with the mine's existing infrastructure. Challenges faced during the implementation phase, such as logistical issues and operator resistance, are addressed, showcasing the adaptability and resilience of the implementation team.

8. Conclusion:

The successful implementation of Online driver fatigue monitoring system at Khondbond Iron & Mn. Mine illustrate the commitment towards safety enhancement. This system successfully generating all the enabled driver abnormalities in real time. The continuous monitoring and action on these alerts significantly reduced the risks of HEMM and Supporting equipment/LMV operation at mines. The operators with true alerts are counselled to create awareness on drowsy driving.

9. Reference:

1. Directorate General of Mines Safety, Ministry of Labour, Government of India, DGMS (Tech) Circular No. 6, 2020, http://www.dgms.net/DGMS(Tech)%20Circular%2006%20of%202020.pdf
2. Driver Fatigue Monitoring system for Mining Application, https://myportservicesindia.com/products/driver-fatigue-monitoring-system/
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