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Belt-Integrated Monitoring of Tensile Loads in Conveyor Belts

Width-resolved in-belt strain sensing for detection of abnormal operating conditions

Belt conveyors are critical infrastructure in mining and bulk material handling, yet condition monitoring remains largely component-centric - focused on drives, idlers, pulleys, and surface damage. The belt itself is the central load-carrying and cost-defining component, but it is not typically monitored in its own right. A belt-integrated view of the internal tension state - especially the tensile-load distribution across the belt width - is therefore a promising approach. Width-resolved tension patterns can reveal asymmetric loading and developing disturbances early, adding a diagnostic layer beyond conventional component monitoring.

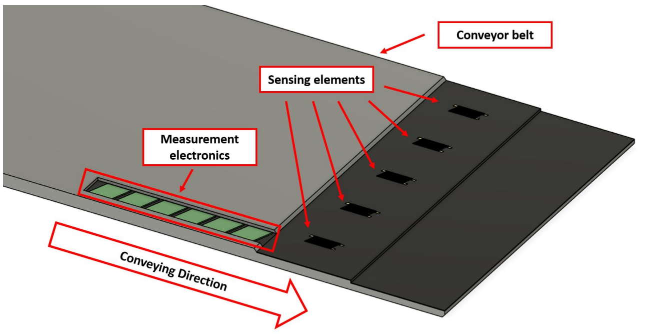

Fig. 1: Schematic overview of the monitoring system

This project develops and validates a belt-integrated monitoring system that measures tensile loads within the belt and reconstructs width-resolved tension profiles during operation. Multiple strain-sensing elements are distributed across the belt width and connected to ruggedized measurement electronics for signal conditioning, data acquisition, and wireless transmission to a base station for processing (Fig. 1). By continuously tracking the tension distribution across the belt width, the system targets early recognition of operating states such as eccentric bulk loading, belt mis-tracking, or localized increases in rolling resistance (e.g., blocked or damaged idlers), which may manifest as characteristic left–right load asymmetries or localized temporal changes.

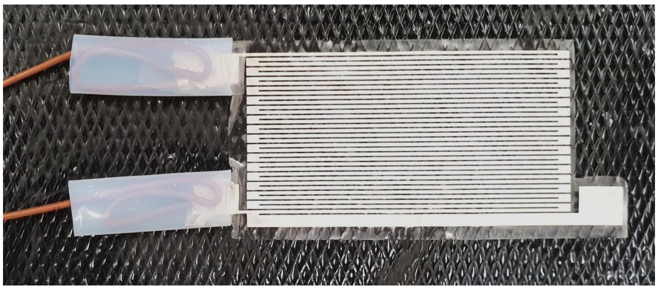

Fig. 2: Strain-sensor before integration

A central engineering requirement is robust integration without compromising belt integrity, particularly in mechanically critical regions such as the splice. The sensing approach, therefore, emphasizes splice-compatible integration and mechanically compliant sensor designs based on printed electronics (Fig. 2). The resulting measurement chain will be validated on a test conveyor under controlled operating conditions and representative disturbance scenarios (e.g., mis-tracking and asymmetric loading). Based on these experiments, evaluation methods will be established, and indicators for abnormal loading conditions will be derived.

Overall, belt-integrated, width-resolved tension monitoring aims to turn the belt from a “black box” into a measurable component, enabling data-driven condition assessment and more transparent operation of conveyor systems.

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Modelling Breakage and Fines Generation of Direct Reduced Iron (DRI) During Handling and Transport

DRI Pellets

WHAT?

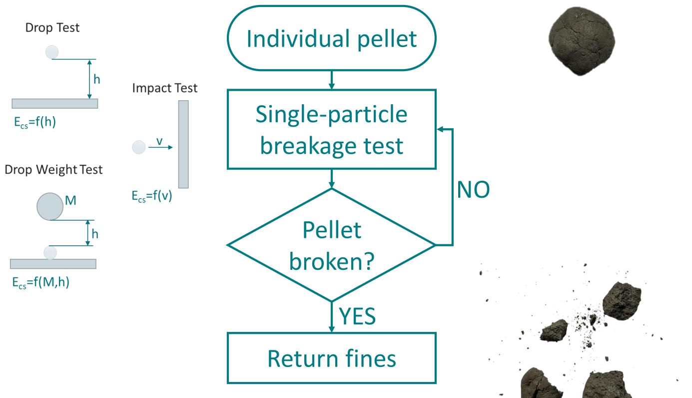
Predict breakage and fines generation of Direct Reduced Iron (DRI) during handling steps using Discrete Element Method (DEM) simulations calibrated with single-particle impact tests.

DRI is a key enabler of low-emission steelmaking, and production is rising rapidly. However, it is difficult to handle: because of its low mechanical strength DRI is prone to break, generating combustible fines and dust. Its high reactivity adds further safety risks: contact with air or (sea-)water can trigger hydrogen formation and heat-releasing re-oxidation that may lead to overheating and self-ignition. Minimising breakage is therefore critical for safe, efficient logistics.

WHY?

- Minimise mechanical degradation of DRI during transport and storage
- Reduce costs and effort for dust and fines handling
- Improve safety and regulatory compliance in DRI logistics (IMSBC Code)

Single-particle impact tests are used to characterize how individual particles break under controlled conditions. Key breakage characteristics are quantified from these test, including the breakage probability (P_b), the post-breakage particle size distribution (PSD), the mass lost per impact, and the rate of damage accumulation.



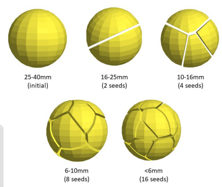
Single-particle breakage characterization

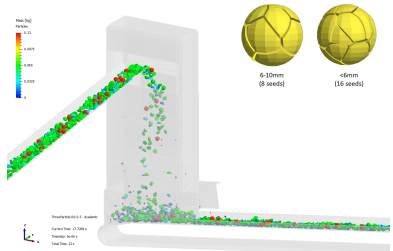
HOW?

- Quantify DRI breakage under relevant loads using single-particle impact tests
- Model DRI breakage in DEM using a particle-replacement approach
- Verify and validate fines prediction in lab-scale systems and industrial applications

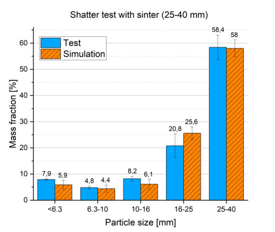
With impact-calibrated DEM, breakage hotspots can be identified, fines predicted for different designs and settings, allowing optimisation ahead of expensive trials

Breakage pattern (Voronoi tessellation)





DEM simulation of particle breakage in a convectional chute



Return fines: test vs. simulation

Reference:
[1] Denzel, M., Prenner, M., Sifferlinger, N.A, Antretter, T., A breakage model for DEM based on a probabilistic particle replacement with Voronoi fragments, Minerals Engineering, 2023, doi:10.1016/j.mineng.2023.108328

Safe H-DRI
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