

Wear-resistant belt bucket elevator design

While belt bucket elevators are a key part of the cement production process, incorrect design or operation can accelerate wear on critical components. However, improved feeding and discharge systems reduce wear on these elevator parts.

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Bucket elevators are indispensable in the cement, lime and power plant industries, as well as in many other industrial applications. They enable energy-efficient material transport and have the lowest energy consumption of all vertical conveying systems. Compared to alternative solutions such as pneumatic conveyors, they can reduce energy costs by up to 66 per cent. The primary energy demand in a bucket elevator is for lifting, with minor contributions from friction and scooping. In contrast, inclined mechanical conveying systems, such as troughed belt conveyors, encounter resistance at each idler (due to bearing friction and belt flexing), leading to energy losses or increased power requirements.

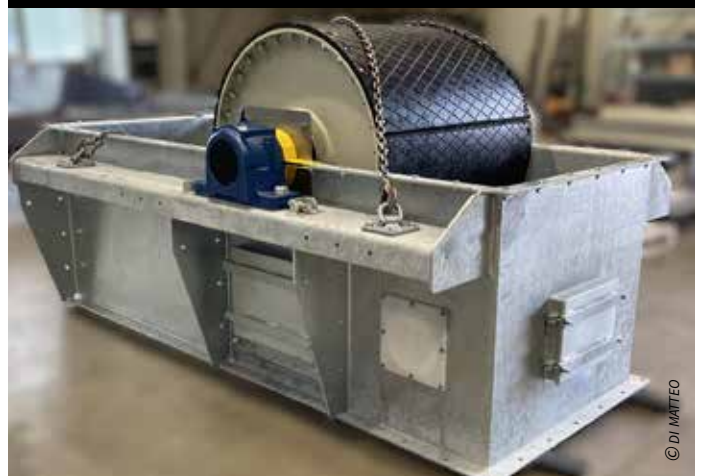
In addition, bucket elevators require minimal space. Alternative conveying solutions, such as inclined troughed or pipe belt conveyors, demand significantly more space, have a limited angle of inclination, and often necessitate steel bridge structures – substantially increasing investment costs.

Germany-based DI MATTEO has decades of unrivalled experience in conveying fine

and coarse high, medium- and low-calorific alternative fuels (AFs), using specially designed belt bucket elevators (DI MATTEO FLEXOLIFT). Despite this, some plant operators, OEMs and design offices remain sceptical

about the feasibility of using bucket elevators for conveying refuse-derived fuel (RDF) or solid recovered fuel (SRF). Incorrect design or improper parameter selection can accelerate wear on critical components, significantly reducing the service life of the bucket elevator. However, in recent years, DI MATTEO has actively addressed these key challenges.

Bucket elevators offer energy-efficient and space-saving materials transport in cement plants



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Belt bucket elevators vs chain bucket elevators for AF transport

As AFs are typically conveyed at ambient temperature, the traction element of a belt bucket elevator has a significantly longer service life compared to that of a chain bucket elevator. In chain bucket elevators, continuous wear occurs due to the constant relative movement between

Figure 1: DI MATTEO high-capacity belt bucket elevator FlexoLIFT



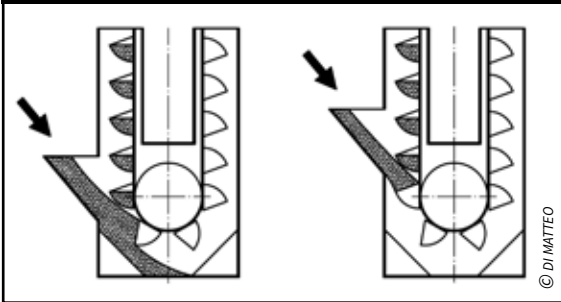
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Figure 2: examples of a worn central chain of a bucket elevator



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Figure 3: comparison of conventional bucket feeding (left) and direct bucket feeding (right)



metal components. This is particularly evident at the chain links in the joint surfaces and at the points where the chain engages with the sprockets or chain rollers (see Figure 2).

Additionally, belt bucket elevators offer advantages over chain bucket elevators in terms of explosion protection. Experience shows that when metal components collide at speeds exceeding 1m/s, the generation of sparks cannot be ruled out. Since bucket elevators typically operate at speeds above this threshold, belt bucket elevators provide a safer solution.

Reduced bucket wear through improved feeding

DI MATTEO bucket elevators feature an optimised inlet chute and positioning, resulting in improved bucket feeding. This ensures that the majority of material is deposited directly into the bucket (so-called direct feeding), while only a minimal amount falls into the bucket elevator boot, where it is subsequently scooped up (see Figure 3).

During the design of the inlet chute,

dimensions were optimised and the inclination angle was adjusted to match the conveyed material and the bucket design.

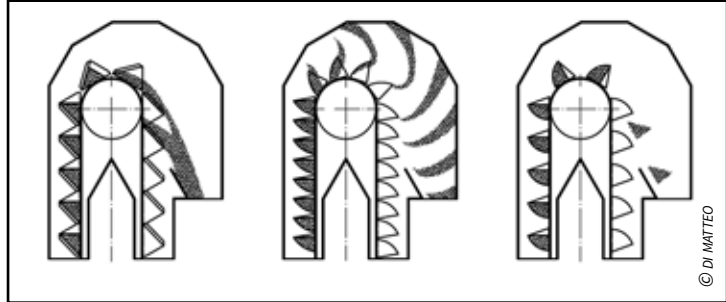
Additionally, a carefully adapted height position minimises the amount of material falling into the boot, thereby reducing scooping forces and lowering bucket wear.

Improved discharge to reduce wear on shaft casing and buckets

Bucket emptying and discharge behaviour play a crucial role in bucket elevator wear. DI MATTEO employs mixed discharge, a method that sits between gravity and centrifugal discharge (see Figure 4). This is the gentlest emptying technique, as the material exits the bucket in bulk and lands directly in the outlet, rather than sliding or being forcefully ejected. As a result, mixed discharge minimises wear on both the buckets and the bucket elevator head.

With gravity discharge (used at low conveying speeds), the material is poured out of the bucket, flowing slowly and sliding over the back of the preceding bucket. This leads to wear on both the inner and outer surfaces of the buckets.

Figure 4: gravity discharge (left), centrifugal discharge (middle) and mixed discharge (right)



With centrifugal discharge (used at high conveying speeds), the material is thrown out of the bucket and impacts the interior of the bucket elevator head, which acts as a slide. This causes wear on both the inside of the bucket and the bucket elevator head.

The primary objective when emptying buckets at the bucket elevator head is to ensure that the entire contents are discharged into the outlet. However, with many conveying materials, this is not fully achieved. As a result, a certain proportion of material falls back down into the boot through the descending shaft casing, where it is subsequently re-scooped by the buckets. This leads to material recirculation within the bucket elevator. Depending on the properties of the conveyed material, the mass flow rate and the presence of foreign objects such as glass, metal parts, or stones, this recirculation can contribute to wear in the descending shaft casing (see Figure 5). Additionally, the increased scooping requirement accelerates wear on the buckets, reducing their service life.

Figure 5: example of worn shaft casing that was repaired by patchwork



Figure 6: practical bucket emptying test (left), image analysis (middle) and DEM simulation (right)

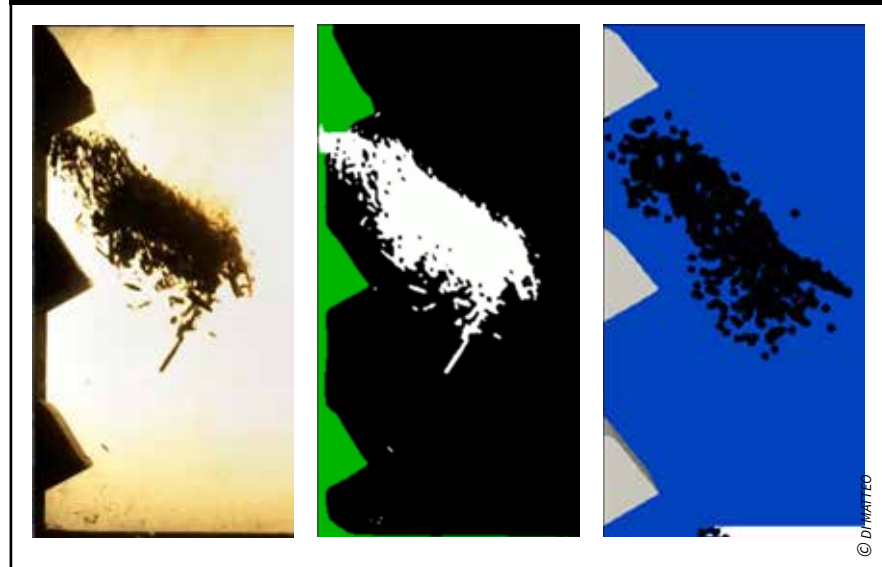
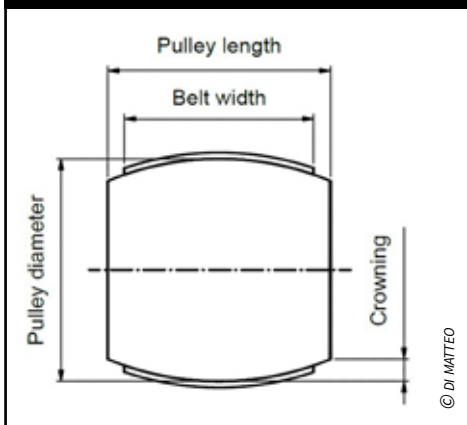


Figure 7: crowned pulley (schematic illustration)



Continuous improvement of bucket design through research and testing

In recent years DI MATTEO has continuously refined and enhanced its bucket designs based on mixed discharge. This development has been carried out in collaboration with various universities and tested extensively in the company's bucket elevator test facilities. As a result, back-fall material has been reduced from 15 to less than five per cent. A wide range of factors has been analysed, including different conveying materials, material properties, bucket designs, pulley diameters and conveying speeds. To optimise development, discrete element method (DEM) simulations have been employed, reducing the need for extensive practical testing (see Figure 6). Additionally, modern

Figure 9: in 2024 installed DI MATTEO bucket elevator at a cement plant in Germany



image processing systems have been used to evaluate test results with greater precision.

Preventing belt misalignment and protecting the belt

To prevent damage caused by belt misalignment, belt misalignment monitors are installed to shut down the bucket elevator if the belt or buckets begin to grind against the housing. However, if these monitors fail or are bypassed, significant wear can occur on the buckets, belt and housing.

To ensure proper belt alignment, DI MATTEO utilises crowned pulleys, which naturally centre the belt during operation and keep it running straight (see Figure 7). However, over time the crowning wears down. To facilitate inspection, the housing is equipped with inspection flaps, allowing easy monitoring of the crowning.

The drive pulley is fitted with segmented and rubberised steel shells, providing enhanced grip and durability. Additionally, an inspection door is located beneath the drive pulley, between the ascending and descending strands. This design allows the pulley lagging to be replaced within a few hours without the need to open the belt, minimising downtime and maintenance effort (see Figure 8).

DI MATTEO uses rubberised drive pulleys to improve the grip between the belt and pulley, preventing slippage and excessive wear during start-up. The rubber coating not only enhances traction but also protects the belt, significantly reducing mechanical

Figure 8: segmented drive pulley lining with large inspection door



wear during stationary operation.

For belt misalignment detection, DI MATTEO employs non-contact, wear-free misalignment switches. These large inductive sensors detect when the distance between the bucket and housing falls below a certain threshold, automatically shutting down the bucket elevator.

Unlike conventional contact-based solutions, which rely on physical contact with the belt edge, this system avoids wear and heat generation.

Stainless steel design to prevent corrosive wear

Alternative fuels such as RDF or SRF can contain aggressive substances that over time may cause corrosion of unprotected metal components. To address this, DI MATTEO ensures that buckets used for conveying AFs are always made of stainless steel.

In a project completed in Germany in 2024, the entire bucket elevator housing – including the head, boot and shaft casing – was constructed from stainless steel (see Figure 9). The previous housing, made of conventional steel, had suffered from material degradation and natural weather-induced corrosion over its 15 years of operation. The plate thickness of the shaft casing had become critical, prompting the complete replacement of the bucket elevator. The stainless steel used in the new design is far more resistant to the aggressive substances in the conveyed material, offering enhanced protection against chemical corrosion.

Application of expertise

The knowledge gained from these developments has also been integrated into DI MATTEO bucket elevators used for conventional bulk materials such as cement, raw meal, clinker, limestone and sand, as well as a wide range of alternative fuels. These advances have led to a bucket elevator design that significantly reduces wear and offers a considerably longer service life, which in turn contributes to a reduced CO₂ footprint. ■