WORLD CEMENT

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WHEN IS A CONVEYOR UPGRADE ACTUALLY A DOWNGRADE?

R. Todd Swinderman, Martin Engineering, outlines the factors that operators must consider when upgrading their conveyor systems in order to ensure their modifications actually improve performance.

When greater production is needed to meet rising demand or when lower quality raw materials require greater amounts to be processed per unit of output in order to retain the same level of production, many operators simply speed up the conveyor. Rather than increasing capacity as intended, speeding up the conveyor often results in reduced capacity, because changes in the trajectory of the discharged material can cause buildup and the clogging of hoppers or chutes, leading to unscheduled downtime.

More tonnage means more carryback, dust, and spillage, degrading workplace safety and increasing labour costs for cleanup. A greater volume and weight could also require a more powerful drive, which may weigh more, requiring structural changes and potentially additional space, limiting access for maintenance.

As plant engineers, operators, and maintenance mechanics make undocumented or unproven changes, over time, the conveyor operation and physical characteristics can morph the system. In some cases, the proper answer to the question, 'Can we increase capacity on the existing conveyor?' should be 'No, we need to start over.'

Original design

Prior to the modification of a conveyor, it is recommended to verify that the current system is operating in an environment and on an application for which it was originally designed. The existing conveyor may have been repurposed over the years by modifying chutes, adding feed points, or changing the slope to accommodate process changes. In situations where the conveyors are many decades old, the original design specifications and drawings could be incomplete or lost.

Figure 1. Adjustments in belt speed and load volume should be accompanied by an in-depth assessment of the system.

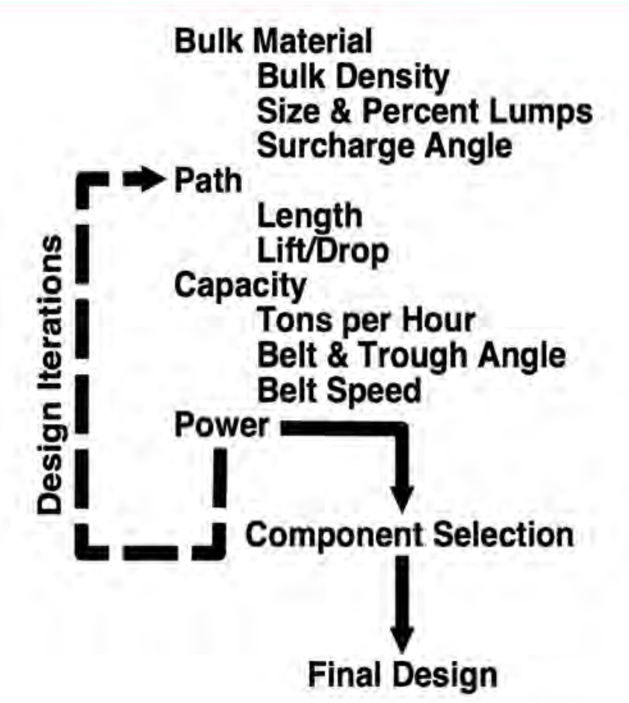

Figure 2. Simplified conveyor iterative design flow chart. This graphic shows the iterative design intent more clearly.

Conveyor design is an iterative process. Purchasing a conveyor at the lowest capital cost is generally accompanied by significant design compromises. Even if it matches previous conveyor structures, the design is likely to use the maximum loading capacity on the narrowest belt, travelling at the maximum speed for the raw material, while only meeting the minimum safety standards and codes.

When sold on lowest price, the supplier's goal is to win the low bid and make it through the warranty period without costly rectifications being required. If the goal was to design a conveyor with the lowest cost of ownership over its intended life, it was likely designed with less than maximum loading, a slightly wider belt, and the capacity to run at a reasonable speed, while exceeding minimum safety standards and code requirements. The best practice is to re-establish the original design intent and compare it to the existing conveyor.

Conveyor technology changes over time, particularly in belting and calculation methods. Until the 1980s, without the aid of computers and design software, conveyors were designed using hand calculations and experience. It is amazing how many conveyor designers still use the 1977 5th Edition (or earlier) of the Conveyor Equipment Manufacturers Association (CEMA) design guide 'Belt Conveyors for Bulk Solids', which relies on research from the 1940s.[1] The 6th Edition indicated that the hand calculation method was an inaccurate predictor of the actual power needed for proper conveying. The most recent 7th Edition requires predicting power within - 0% to + 10% of actual. Much research and development has been conducted in regard to conveyor power requirements, which has resulted in several low-cost design software options (Figure 2).

Upgrade design

First, define the problem the conveyor upgrade plan is trying to solve. It may seem obvious, but a lack of understanding of the primary reason(s) for an upgrade could cause suppliers to address symptoms rather than root causes. The new design might not address the primary need for a performance upgrade.

For example, if the chutes are plugging or there is a spillage, then it might not be a conveyor issue, but instead an operator or maintenance issue. If the problem is belt damage, mistracking, or tripping the breakers, it may be due to a misalignment of the structure and idlers. Surge loading the conveyor in an attempt to catch up for lost time spent cleaning could result in more spillages.

The bulk material

Another critical early step in an upgrade project is understanding the physical properties of the material being handled. Knowledge of properties such as solid density, bulk density, and particle distribution are crucial to a well-designed conveyor. Original test results for the material are likely out of date due to changes in the sources and variations in the extracted raw cargo over time.

Discrete element modelling (DEM) software helps model the flow of bulk solids through chutes and onto conveyors. Laboratories can perform the tests, or operators can conduct their own basic tests using the information in the CEMA publication, ANSI/CEMA Standard 550 – Classification and Definitions of Bulk Materials.

Figure 3. Curtains can control the bouncing or rollback of round particles.

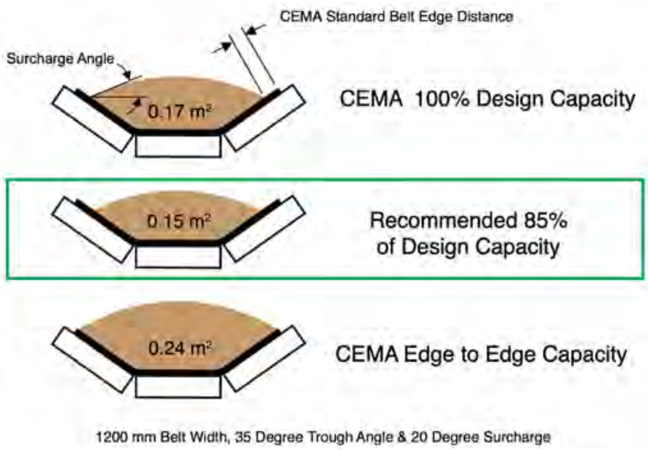

Figure 4. CEMA Standard belt edge distance recommendations.

Component standardisation

It is usually desirable to try to use belting, idlers, and other components that are available elsewhere at the site or are common supplier stock items. This may not always be possible, but the capital cost alone should not necessitate a suboptimal design solution. Because increased tonnage might escalate idler loads, rolling components may require a higher load capacity to obtain an acceptable lifespan. As such, operators should consider the life cycle costs of their design and component selections.

Loading and transition

One of the biggest contributors to belt damage and the release of fugitive materials is loading the conveyor before the belt is fully-troughed, in a process called 'loading on the transition'.

Loading on the transition best practices:

- If space permits, rectify the loading so that it starts at the second fully-troughed idler.
- Vertical curves, if properly designed, are not an issue, but the design calculations need to be verified if the belting or tonnage changes.
- Using bend pulleys for convex curves rather than a spaced array of troughing idlers should be avoided, because it is often a source of spillage.
- Diverter ploughs and other devices, which tend to force the belt to one side or the other, should be located where the belt has enough distance to return to running centred in the idlers.
- When loading round particles or operating in wet environments, a belt incline of 5° or less will help create a mass that prevents rolling or fluid cargo

Table 1. Comparison of capacity increase by changing idler trough angle (1200 mm wide belt and 20° surcharge angle).

Trough angle 3- equal roll idler	CEMA 100% cross-sectional area (m³)	Increase in cross-sectional area from flat belt.	Increase in cross-sectional area from 20° trough angle	Increase in cross-sectional area from 35° trough angle.
Flat belt	0.064			
20°	0.132	106%		
35°	0.168	163%	27%	
45°	0.181	183%	37%	8%

from flowing backward toward the tail pulley. The best practice is to load horizontally and then transition into the slope.

- For round-shaped material, consider installing curtains along the slope to knock down bouncing particles and allow them to form into a stable profile.

Belt width and trough angle

The trough angle is initially selected based on experience or the existing idlers for standardisation. Belt width is selected by calculating the cross-sectional area of the bulk material by assuming a troughing angle, an idler with 3 equal roll lengths, as well as the surcharge angle, lump size, and flowability of the bulk solid being handled. There are two important cross-sectional areas to consider, CEMA 100% full, and full edge-to-edge. The 100% full area is based on a standard belt edge required to prevent spillover between idlers as the belt sags on the carrying run. The full edge-to-edge loading is used to calculate the maximum potential load on the structure. The best practice is to select the belt width based on 85% of the CEMA 100% cross-sectional area to allow for surge loads, off-centre loading, or normal mistracking (Figure 4).

If the upgrade is to prevent spillage from mistracking, it may be possible to use a non-standard belt width, because the wing lengths of most troughing idlers allow more room than what is considered acceptable for mistracking belts. It may also be possible to change the standard trough angle or use a custom-designed idler to allow for more cross-sectional area. Two common techniques can be incorporated into a new or complete conveyor design to make future upgrades less costly.

The first technique is changing the trough angle of the idlers which raises the capacity by increasing the cross-sectional area. In new designs, consider using 20° idlers. Upgrading to 35° idlers represents a 27% increase in cross-sectional area, and going from 20° to a 45° trough angle is a 37% increase. Although 35° idlers are fairly standard, it is important to note that for retrofit upgrades, going from 35° to 45° idlers is only an 8% increase in cross-sectional area (Table 1).

A second common technique for new construction is to design the structure for the next wider belt width and use CEMA wide-base idlers. The mounting dimensions of the wide-base idlers allow for future replacement with a wider belt. For example, if the structure for the 1200 mm (48 in.) wide belt and 20° surcharge angle using 35° trough idlers was designed for wide base idlers, the belt width could be increased to 1400 mm (55 in.), resulting in a 33% capacity increase with the same trough angle and belt speed. Changing from a 35° to 45° trough angle and the wider belt and idlers would result in a 90% increase in cross-sectional area. This method is not often used, because there is resistance to increasing capital costs for a wider and higher load-bearing structure, higher material mass, and larger drive. However, it is an excellent approach if capacity is expected to increase in the future.

Figure 6. Raising belt speeds and volumes have consequences for transfer chutes and cleanup.

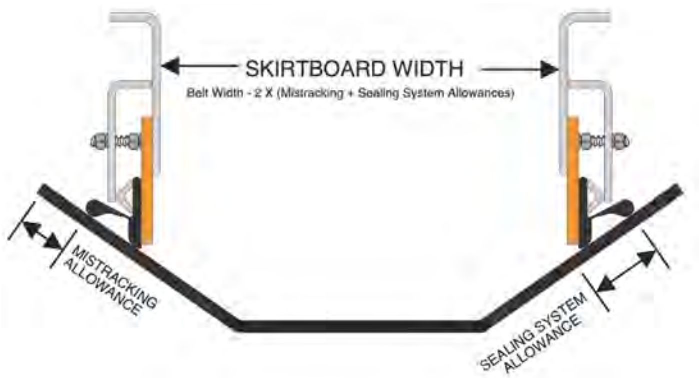

Figure 7. Mistracking allowance + sealing system allowance x 2 = skirtboard width.

Belt speed

CEMA provides some guidance on belt speeds for different classes of material in Chapter 4 of Belt Conveyors for Bulk Materials 7th Edition. Generally, a wider belt operating at a lower speed will reduce fugitive material release, since the potential for fugitive material release is directly proportional to belt speed and capacity. The lower

CEMA-recommended belt speeds should be used in the first iteration of the design. Then additional iterations can be tried by changing the belt width, trough angle, and belt speed to arrive at a reasonable solution.

Discharge chute

For a capacity increase, the discharge chute will need to be closely reviewed. The trajectory path should be plotted so that the stream of material impacting the chute does not create a situation where there is zero or negative vertical velocity on impact with the chute. If the material can stay suspended at the impact location, it will increase the chance of buildup and blockage of the chute. If the angle or liner is changed, it must not create a slow flow situation where material backs up and accumulates in the chute. The discharge chute's cross-sectional area should be a minimum of 4 times the cross-sectional area of the loose bulk solid.

Receiving chute

The design of the loading chute and skirtboards requires close attention to detail to minimise fugitive material release. CEMA uses two-thirds of the belt width for the inside dimension of the loading chute skirtboards, regardless of belt width. Idler fouling and spillage can happen when uneven loading causes the belt to drift to such a degree that there is an opening between the inside of the chute wall and the edge of the belt where material can escape. Best practice in design considers the amount of allowable mistracking plus the thickness of the sealing system to determine the distance from the edge of the belt to the outside of the skirtboards as the minimum dimension on each side (Figure 7).

Figure 8. Having safe and available access to components is part of design best practices.

Maintenance access

If an operator upgrades their capacity but cannot access it for maintenance or cleaning, what have they accomplished? This detail is often overlooked. Any upgrade plan should include work platforms and upgraded access. Make sure all the old piping conduits and unnecessary structures are removed. Evaluate guarding and lighting to make inspections easier and more accurate. Provide the necessary power, compressed air, or vacuum utilities needed for maintenance or cleaning.

Conclusion

There can be a significant benefit to upgrading when the entire system design is considered. There should be an expectation of increased productivity. Additional benefits should include reduced fugitive material release by improved passive dust control and belt cleaning, saving on maintenance time due to improved access and a reduction in safety incidents due to reduced cleanup and maintenance-friendly changes.[2] ■

References

1. Belt Conveyors for Bulk Solids, 7th Edition, Conveyor Equipment Manufacturers Association, 2014.
2. Foundations for Conveyor Safety, Martin Engineering, 2010, chapters 31 - 34, 2016.

About the author

R. Todd Swinderman earned his B.S. from the University of Illinois, joining Martin Engineering's Conveyor Products division in 1979 and subsequently serving as V.P. and General Manager, President, CEO and Chief Technology Officer. Todd has authored dozens of articles and papers, presenting at conferences and customer facilities around the world and holding more than 140 active patents. He has served as President of the Conveyor Equipment Manufacturers' Association and is a member of the ASME B20 committee on conveyor safety. Swinderman retired from Martin Engineering to establish his own engineering firm, currently serving the company as an independent consultant.