The high cost of overdesigning your belt conveyor

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Are you in the market for a new troughed belt conveyor? Maybe you want it to be a heavy-duty unit like your other conveyors so they can all share the same parts inventory. Or, to avoid spending time analyzing your application details, you may just want to specify a conveyor with oversized parts that you know will handle the job. But before you tell your conveyor supplier to “Supersize it,” consider whether this will make the conveyor a lot more expensive to build and run than necessary. Using the example of how one plant specified more conveyor than it needed, this article explains how much an overdesigned conveyor can really cost.

Consider how a troughed belt conveyor was recently overdesigned for its application in a glass producer’s plant. The producer’s plant engineer gave design parameters for a new, relatively small troughed belt conveyor to a belt conveyor supplier. The plant engineer specified that the conveyor would carry glass batch with a 90-lb/ft³ bulk density horizontally for 50 feet at a nominal capacity of 100 t/h. The conveyor would operate 24 hours per day, 365 days per year, but would carry material only 20 percent of the time, running empty for the remaining time.

But the plant engineer was afraid this conveyor might not handle the application and wanted it to have larger components. To satisfy the engineer, the supplier beefed up the conveyor design, increasing the belt width to 30 inches, the idler roll diameter to 5 inches, and the drive motor horsepower to 5, with a corresponding belt speed jump to 240 fpm. Undoubtedly, this overdesigned conveyor would more than handle the assigned task. But the plant engineer hadn’t considered this conveyor’s high cost — both short- and long-term.

The overdesigned conveyor’s short- and long-term costs

The short-term effect of using the larger components is that the conveyor will cost more to fabricate. The overdesigned belt, idlers, and drive motor and gear reducer, along with the related size increases in belt cleaners, skirting, and other components, will all boost the fabrication cost. In some cases the larger drive motor also requires higher-cost electrical components, such as a larger motor starter and heavier wiring.

The long-term effect of using overdesigned components is that the belt conveyor will use more energy and thus cost more to operate year after year.
Calculating the overdesigned conveyor's operating cost

Most of the work done by a small, horizontal, troughed belt conveyor is moving the belt and turning the idlers and head and tail pulleys. This work is from the empty-belt friction force. For the overdesigned conveyor, this force was increased slightly by the greater weights of the conveyor's larger belt, idlers, and head and tail pulleys. Yet the actual power required to run the conveyor doesn't depend solely on the empty-belt friction force — instead, it's defined as the rate of work. This rate is simply the empty-belt friction force (in pounds) multiplied by the belt's velocity (in feet per minute). The equation for calculating the horsepower for a belt conveyor motor in US units (ignoring the effects of drive system inefficiencies) is:

\[ HP = \frac{F \times V}{33,000} \]

where \( HP \) is horsepower, \( F \) is the force (in pounds) required at the drive pulley to pull the belt (typically called empty-belt friction force when the belt is empty and belt pull when it's loaded), and \( V \) is the belt speed (in feet per minute). From this equation it's clear that increasing the empty-belt friction force (\( F \)) will increase the drive system's horsepower requirements. But the greatest effect on power consumption is the resulting belt speed (\( V \)) increase from 150 to 240 fpm.

Let's analyze the amount and cost of the electricity required over a given time to operate each conveyor — the one proposed by the supplier and the overdesigned conveyor desired by the plant engineer. This requires a detailed engineering analysis of the conveyors' component weights, belt tensions, drive system inefficiencies, and operating parameters.

When a plant has several large belt conveyors, overdesigning them produces a huge cumulative increase in the plant's annual energy costs.

The empty-belt friction for the proposed conveyor is 438 pounds. For the loaded conveyor, the belt pull is 490 pounds. Because the conveyor will run empty 80 percent of the time and run with a load only 20 percent of the time, we can calculate the average belt pull with the formula:

\[ F = (438 \times 0.8) + (490 \times 0.2) = 448 \text{ pounds} \]

For the overdesigned conveyor, the empty-belt friction is 446 pounds and, when the conveyor is loaded, the belt pull is 493 pounds. So we can calculate the average belt pull as:

\[ F = (446 \times 0.8) + (493 \times 0.2) = 455 \text{ pounds} \]

To calculate the energy costs of operating each conveyor, we can use the equation 1 horsepower equals 0.746 kilowatts and assume that electricity costs 5¢/kWh and that the drive system's total efficiency is 85 percent.

We calculate the power consumption (\( P \)) for the proposed conveyor as:

\[ P = \frac{448 \text{ pounds} \times 150 \text{ fpm}}{33,000} \times \frac{1}{0.85} \times 0.746 = 1.79 \text{ kilowatts} \]

and for the overdesigned conveyor as:

\[ P = \frac{455 \text{ pounds} \times 240 \text{ fpm}}{33,000} \times \frac{1}{0.85} \times 0.746 = 2.90 \text{ kilowatts} \]

These results show that the overdesigned conveyor will consume 62 percent more electricity than the supplier's proposed conveyor. Using electricity's assumed cost, the annual operating cost for the proposed conveyor is:

\[ 1.79 \text{ kilowatts} \times 8,760 \text{ h/y} \times 0.05 \$/\text{kWh} = 784 \]

For the overdesigned conveyor, the annual operating cost is:

\[ 2.90 \text{ kilowatts} \times 8,760 \text{ h/y} \times 0.05 \$/\text{kWh} = 1,270 \]

This equals a difference in annual operating costs of $486. Over a 10-year period, this cost difference will amount to $4,860 in unnecessary operating expenses for the overdesigned conveyor.

These calculations point out the high cost of overdesigning just one small belt conveyor in a plant. When a plant has several large belt conveyors, overdesigning them produces a huge cumulative increase in the plant's annual energy costs.

Overcoming the temptation to overdesign

It's true that performing a belt conveyor engineering analysis can be tedious and time-consuming. The process requires examining many variables, including your application's material loading conditions, material lump size, capacity requirements, operating temperatures, and maintenance requirements, and then determining how these will affect the conveyor's idler sizes and spacing, head and
tail pulley sizes, belt tension and speed, and skirting length, just to name a few.

But before you short-cut the process and simply supersize your conveyor, consider the real costs of overdesigning and how they’ll add up over the long term. By properly analyzing your application, you can design a conveyor that not only conveys your material as it should but costs less to fabricate and operate.

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Reference

For further reading
Find more information on belt conveyors in articles listed under “Mechanical conveying” in Powder and Bulk Engineering’s comprehensive “Index to articles” (in the December 2000 issue and at www.powderbulk.com).

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