Differential Gearboxes Ensure Wire and Cable Quality and Consistency

A gearbox can offer far more than just speed reduction

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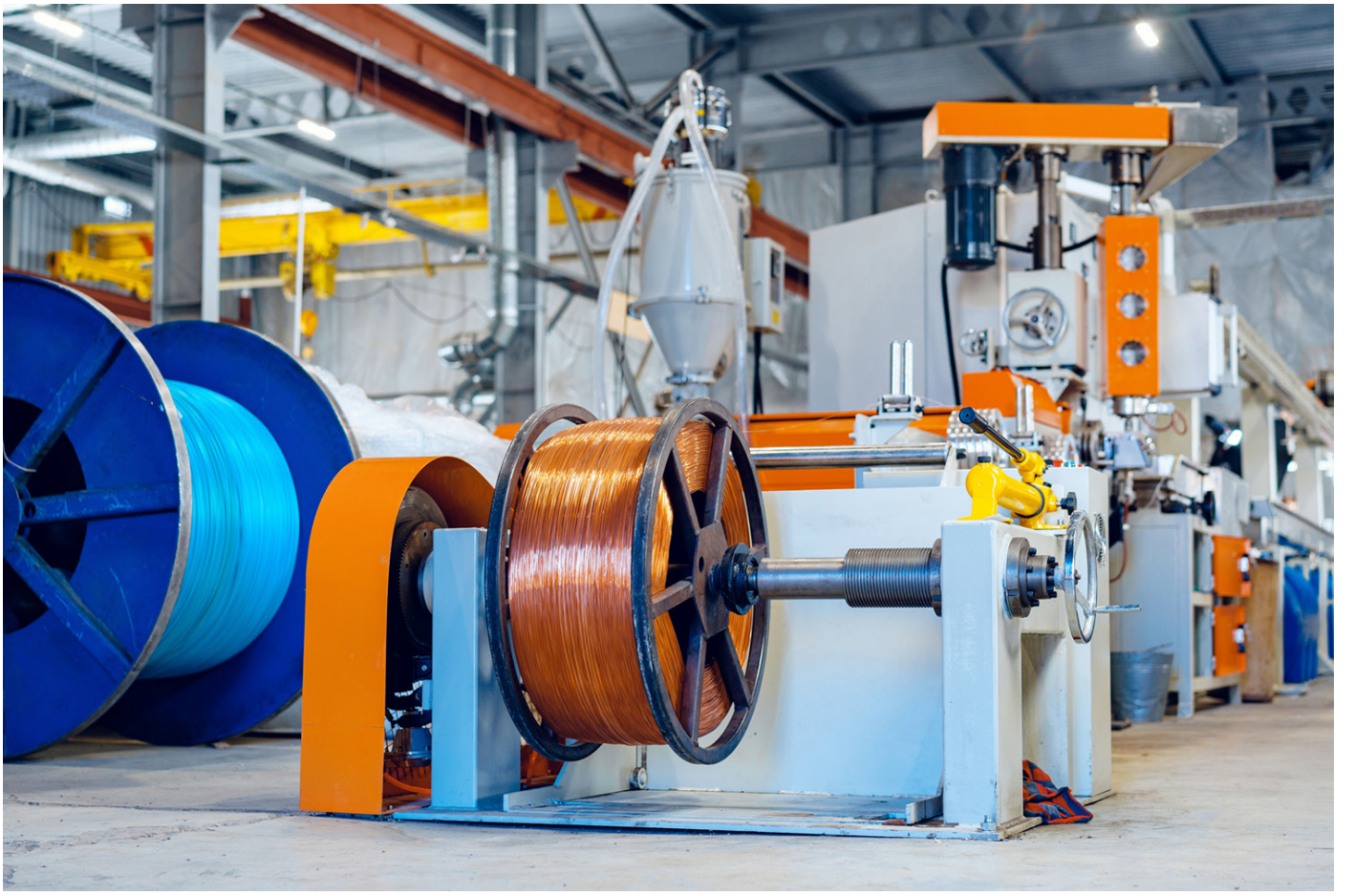


Demand for specialty wire and cable—fueled in part by data center expansion as well as new charging stations for electric vehicles (EVs)—is in turn creating greater demand for cable production capacity. As you design machines that will satisfy the demand, you'll want to incorporate an effective driving method that controls speed and torque with the highest precision.

Multi-speed gearboxes were once popular for differential applications in many industries—including wire and cable—but they have recently been displaced by new servo drives that provide various benefits. However, differential gearboxes offer far more capability than only speed reduction. In fact, for forming and twisting applications, there's no better solution than a differential gearbox.

This article will explain how a certain class of differentials is designed to deliver high torque and precise control of multiple speeds using smaller motors. With these capabilities, you can solve many motion challenges. Here's an overview of how this class of differentials performs in typical wire and cable manufacturing equipment:

Twisting Applications

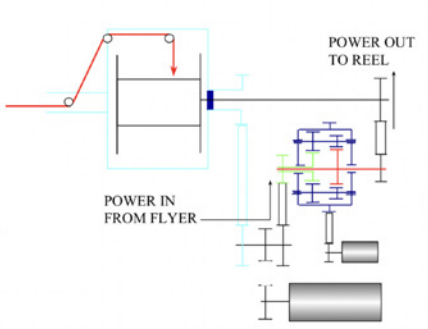
Machines that twist or form wire have one element that holds back (or brakes) the wire, and another element that handles pulling or driving. This situation requires a lot of power—braking power and driving power. In many instances, one motor provides braking power, and another motor does the driving. Each motor must be sized accordingly. However, another approach uses a differential gearbox to provide input power to the wire. This technique is particularly attractive for bunchers and armoring machines.

A typical differential drive on a single twist buncher has two inputs and one output. When the reel rotates, the wire is rewound. A rotating flyer twists the wire without rewinding. When both rotate together, the lay (or pitch) is determined by the following formula:

$$\text{lay} = \frac{\text{wire linear speed}}{\text{flyer rotation speed}}$$

The flyer rotates at a constant speed while paying off the wire. As the wire gathers on the reel, its diameter increases. The reel speed must decrease to achieve a constant linear speed and, ultimately, a uniform lay. Because the speed change occurs dynamically, a machine designer has two options: use two motors—one for each rotating element—or a differential and one motor.

One such differential-based system uses a main motor to drive the flyer and a Redex SR Series planetary gearbox to drive the reel. This system only requires input power for the wire, which is equal to the driving power minus the braking power. The SR Series is also available in an inch bore version, the SA Series.

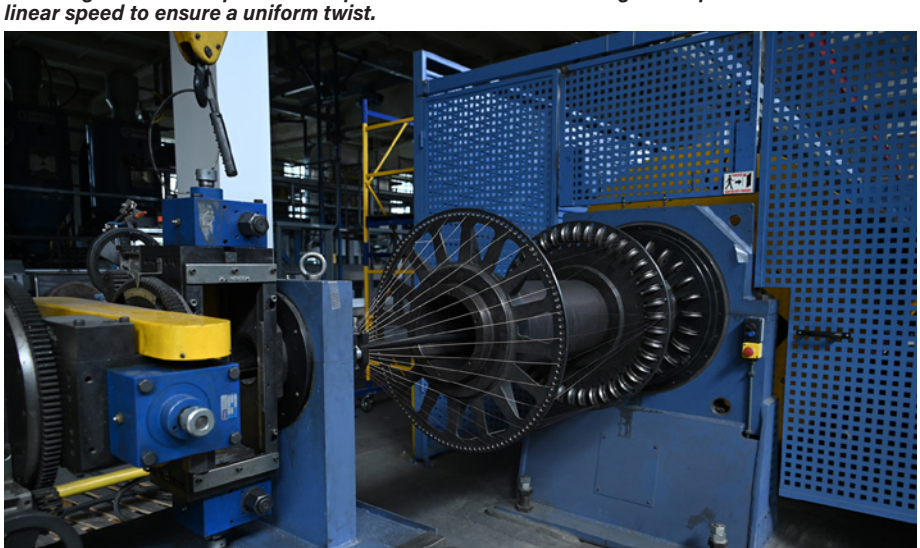


Because power circulates through the SR differential, the system only requires input power for the wire, which is equal to the driving power minus the braking power.

The SR differential has a unique compound epicyclic gearing design that incorporates two sun gears within the casing along with two gears for each planet axis. Redex's patented assembly process ensures equal load sharing between the planet gears: As planet gear assemblies are added, the torque capacity of the differential increases. The SR unit is designed and constructed to allow power to circulate through the differential so that one element is braking and the other element is driving. Furthermore, there is a large ratio between the drive motor and the driven reel. Therefore, a large change in motor speed affects a small change in reel speed, which makes the speed control and, in turn, the lay, very accurate during winding. The result: lower wire-insulation costs and a better bottom line for your bunching operation.

When an armoring machine winds the metal cover, the wire or cable travels linearly through an aluminum or steel shaft. A coil rotates as forming rolls shape the metal material and wrap it around the wire with accuracy. The forming rolls must lay the material accurately, and the coil needs to provide the right tension to unwind the sheathing material. The consequences of inconsistent twists include poor mechanical stability, failure to meet the application's cable diameter requirements or even noncompliance with international standards. Correct armoring avoids these problems, and a uniform twist depends on precise control of the forming roll's speed relative to the linear speed.

Armoring machines depend on the precise control of the forming roll's speed relative to the linear speed to ensure a uniform twist.



Like the single twist buncher example, a typical armoring machine may incorporate two separate motors to power each rotating element. Each must be sized and will occupy significant space. However, a differential gearbox featuring a compound epicyclic gearing design is more effective and efficient for this application. While the differential must be sized to support the full power, the motors only need to input the power that the cable or wire needs. This means the differential allows a smaller motor to do the same job and, depending on the chosen speed ratio, provides precise speed control.

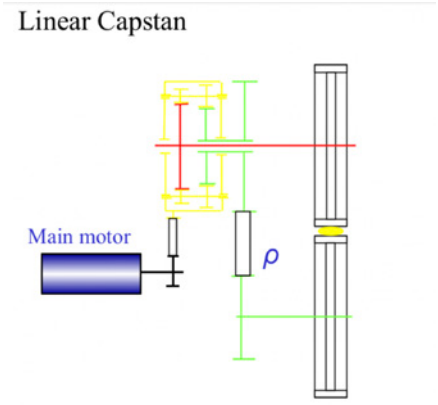
A differential is also ideal for controlling the coil's tension. Although clutches can be fastened directly to the coil, this approach often requires slip rings to activate the clutches and adds maintenance expenses to the assembly.

Tensioning Applications

Whether driving a linear or dual wheel capstan, a requisite balance of torque and speed must be maintained to avoid slipping between the belts and the cable, thus ensuring both product quality and consistency.

"Caterpillar"-type linear capstans employ two belts that rotate at the same speed to pull the product through the processing line at a constant tension. If the capstan's cable tension is unstable, equipment used for extrusion, winding, paying off or other processes down the line will be out of sync, resulting in diminished product quality and possibly costly damage to the capstan itself. Because constant cable tension is essential, the system that drives the belts is critical to maintaining a processing line's precision and, ultimately, delivering a better product. Here's why the right drive system makes a difference in product quality:

You can drive a two-belt system by using a differential or employing a motor with two rigid fixed gear reducers. The gear reducer approach is prone to variations in the belt pulley's diameter, which can cause the two belts to run at different linear speeds. Even the slightest speed differences will cause rubbing and slipping between the belts and the product, which in turn causes the products or the belts to wear. Depending on the application, belt replacement can get expensive.



Using the Redex SR differential with a linear capstan, the input speed defines the sum of the output speeds, and torque equilibrium ensures constant linear speed. The SR also automatically reverses the direction of rotation of the two outputs, thereby providing a reduction from the motor.

In a linear capstan, a differential with one input automatically reverses the direction of rotation between its two outputs and drives the upper and lower belts. This balances the torque between the two outputs and, consequently, balances the speed. If the belt diameters vary, the linear speed remains the same for the top and bottom belt. The result: no slipping and wear for the wire or cable. Taken together, the differential performs three functions in the linear capstan: It ensures a constant linear speed, reduces the speed and reverses the direction of rotation.

For a dual-wheel capstan, the wheels pulling the cable also must have identical torque, but the rotational speed can vary to accommodate diameter differences and maintain a constant linear speed between the wheels. Like a linear capstan, it also requires an effective driving method to maintain the necessary balance of torque and speed to avoid slipping between the belts and the cable.

For dual-wheel capstans, the differential balances torque and speed to ensure a constant linear speed between the capstan and the product, thereby preventing wear on the product or capstan wheels.

The SR differential from Redex USA is well-suited for this type of application, thanks to a compound epicyclic gearing design that incorporates two sun gears within the casing along with two gears for each planet axis. Redex's patented assembly process ensures equal load sharing between the sun gears. It can be installed between the wheels using one input and two outputs. The output speeds can vary slightly to accommodate diameter differences on the capstan wheels. This differential corrects any variations in wheel diameters, eliminates transmission errors and drives the capstan wheels in the same rotational direction. This allows effective linear speed control and ensures precise pulling forces between the capstan wheels.

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Tailor a Differential Gearbox to Meet Your Need

Redex USA has extensive technical expertise and customization capabilities to help you implement the best differential for the job. When you provide our experts with your force and speed requirements along with the pertinent measurements for belts and wheels, we can use that information to help determine a proper differential size as well as help calculate the speed of the motor to establish the differential's gear ratio. Standard options include various timing belts or v-belts for the outer casing as well as coupling options.

High Torque and Speed Control Means Greater Cable Quality

As you design new wire and cable manufacturing equipment to satisfy the growing need for specialty cables in the data center and EV industries, your success will depend on precise torque and speed control throughout your production line. Differential gearboxes deliver high torque output and speed control with exceptional precision, making them ideal for the wire and cable industry's performance and product quality requirements.

Redex SR and SA differentials, with compound epicyclic gearing system and multiple planet trains, offer higher torque capability and a wide range of reduction ratios that ensure the greater precision and speed control that wire and cable production equipment demands. Redex sales engineers can help you determine the appropriate planetary gear reducer for your specialty wire and cable manufacturing application.

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