Regal Rexnord

Higher Plant Efficiency Due to Optimal Backstop Design

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Overrunning clutches and backstops play a fundamental role in heavy industry such as mining and iron and steel, but also in food processing and all applications in which goods and materials are moved by conveying equipment. Their principal task is to prevent reverse running and uncontrolled acceleration of the system in the event of a drive failure (e.g. loss of supply voltage). It is important, therefore, that these components are specified and designed with a high degree of precision.

Dr. Torsten Kretschmer, Technical Director at Stieber GmbH, explains what is involved in the design of backstops and cites important aspects in connection with safety regulations to be expected in the future.

Backstops are a fundamental safety component for preventing an uncontrolled change of direction and speed under the influence of gravity. A fully loaded, blocked belt conveyor system can impose huge torques on the drive. However, with the right know-how and an in-depth knowledge of the prevailing conditions of use, it is possible to design the backstop in a compact and cost-efficient manner and still safeguard the drive train reliably against overload. Backstops also merit closer attention from the point of view of technical aspects of occupational safety and health and accident prevention.

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Design Principles

To design the backstop correctly, the plant designer requires exact data regarding the torques present on the conveyor line. In cases of doubt, many customers and designers work with a larger safety factor, although it is naturally desirable to avoid over-sizing and unnecessary costs.

Plant operators should therefore give the job of determining the actual imposed loads to experienced design engineers, who are able to calculate them very accurately. This information helps the overrunning clutch manufacturer in turn, working in tandem with the customer, to coordinate the performance data of the backstop precisely to the torques to be expected.

In the ideal case, the backstop is designed in parallel with the drive unit, because the motor and gearbox play a key role for its sizing and performance requirements.

Backstops can either be flanged directly onto the transmission housing on the high-speed reducer shaft or mounted externally on the shaft end of the low-speed reducer shaft. For reasons of greater ease of servicing some users prefer to have a reducer mounted separately from the headshaft. In this case an external backstop between the headshaft and the reducer is the best solution because the reducer can be removed without having to block the belt.

Using this design approach, the backstop clutch assembly must have a suitably high torque capacity, which is reflected in the physical size and possibly the procurement costs. If the aforesaid advantages for maintenance can be sacrificed, a reducer-mounted backstop design is commonly recommended. Since the torque loading is lower here than with external mounting, it can normally be of smaller dimensions and be purchased at a lower price.

Load Balancing and Torque Limiting

The number and configuration of backstops are dependent, for the most part, on the application. On conveyors with multiple drives and a corresponding number of backstops that do not have torque limiting, it should be assumed that minimal load balancing takes place. The reason for this is the delayed engagement of the various backstops (BS) as a result of tolerances of all components in the drivetrain, different belt elongations, different friction states (efficiency rates) in the belts, etc.

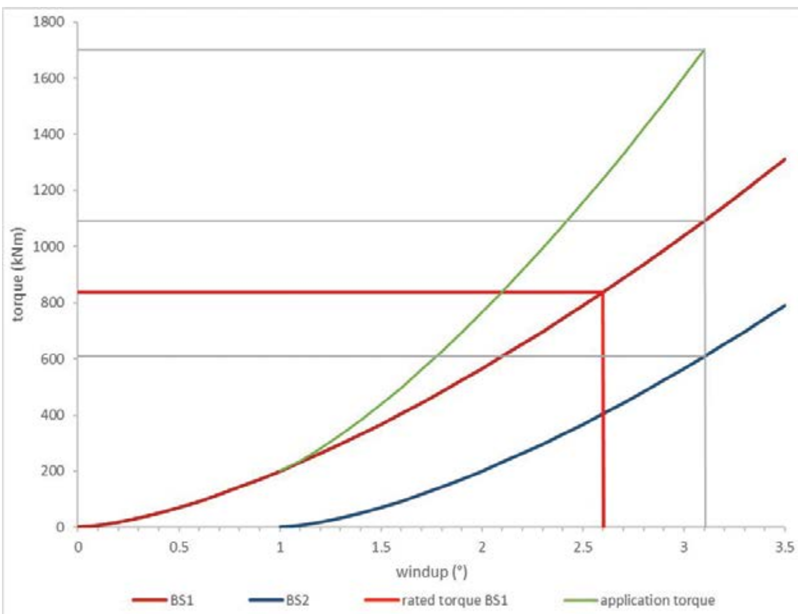


Figure 1: Torque increase in a multiple-drive plant

Figure 1 clarifies this scenario. It is shown that BS1 has to transmit considerably more torque than BS2 – in an extreme case, even the entire reverse torque. In practice, safety factors of up to 3 times the drive torque can be required. Load balancing between BS1 and BS2 does not take place in this situation. The purpose of BS2 can then only be a safety backup, which at the same time means however, that BS2 must be designed with the same safety factor as BS1. It isn't hard to see that both BSs turn out to be disproportionately large in this way.

Figure 2 shows the measurement results for the torque experienced by two standard backstops without torque limiting, which are installed on a shaft. The results show that a 20% higher torque is present on one of the two backstops – with corresponding consequences for the design.

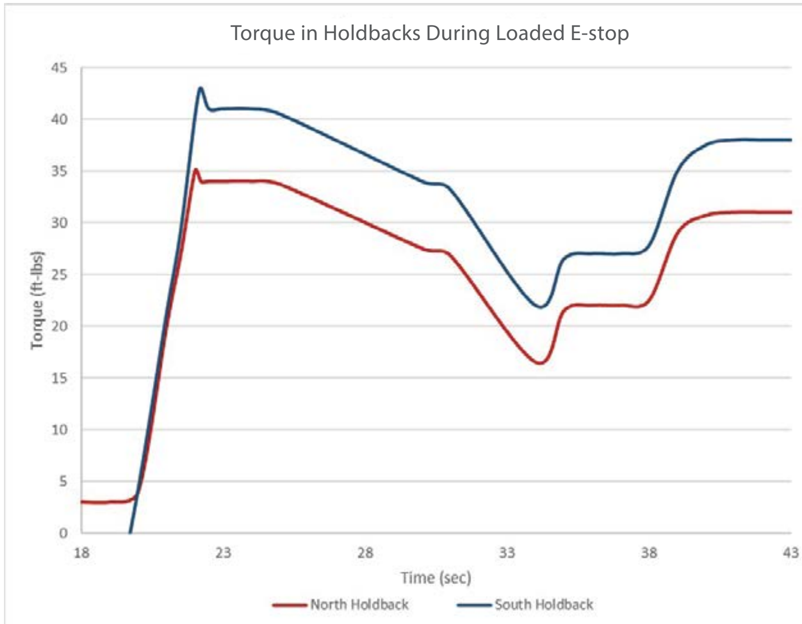


Figure 2: Torque at two backstops without torque limiting

The load balancing can be improved by means of torque-limiting backstops, so that the backstops can be designed smaller without reducing safety. Two design configurations for real world examples for the low-speed shaft and the high-speed shaft can be demonstrated below for this scenario as shown below:

Design for the Low-Speed Shaft

Application: Overland belt conveyor with backstops without torque limiting on the slow-running shaft

Drive output	3200 kW
Safety factor (customer specification)	1.5
Speed of head shaft (backstop)	55 rpm
Return torque of the loaded belt	53 kNm

Customer specification: The backstop must overcome the torque loading following an aborted start.

$$\text{Required torque capacity of the backstop} \geq \frac{3200\ \text{kW x } 1.5 \text{ x } 9550}{55\ /\ \text{min}} = 833.5\ \text{kNm}$$

The calculation for backstops with torque limiting on the low-speed shaft is completely different. In this case, the backstop is adjusted so that it can safely transmit the return torque of the loaded belt (safety factor: 1.3).

Slipping torque of the backstop ≥ 53 kNm x 1.3 = 68.9 kNm

In the case of an aborted start, the backstop slips until nominal torque is reached and the excess tension in the belt is relieved.

Design for the High-Speed Shaft

Application: Inclined conveyor with backstops without torque limiting on the high-speed shaft

Drive output	950 kW
Safety factor (customer specification)	1.5
Speed of high-speed shaft	500 rpm
Return torque of the high-speed shaft	15 kNm

$$\text{Torque capacity of the backstop} \geq \frac{950\text{ kW x }1.5\text{ x }9550}{500\text{ / min}} = 27.2\text{ kNm}$$

In this case the customer selected a standard backstop with a maximum torque capacity of 72 kNm, which was damaged during an aborted start with an overloaded belt. Even a higher safety factor or the installation of a bigger backstop would not be a remedy for this situation, purely because the reducer is not designed for this load and a backstop with suitable torque capacity no longer fits onto the reducer shaft from a size standpoint.

By contrast, a torque-limiting backstop with a suitably adjusted slipping torque and a high speed capacity in slipping mode is an effective solution for this loading situation.

Backstops with torque limiting on the high-speed shaft: the backstop is adjusted so that it can safely transmit the return torque of the loaded belt (safety factor: 1.3).

$$\text{Slipping torque of the backstop} \geq 15\text{ kNm x }1.3 = 19.59\text{ kNm}$$

In the case of an aborted start, the backstop slips until nominal torque is reached and the excess tension in the belt has been relieved.

As can be gathered from the design examples, torque-limiting backstops, which can safely hold the restoring torque (safety factor 1.3), can be specified that are much smaller than a conventional backstop without sustaining damage in the event of an aborted start. Stieber recommends a safety factor of at least 1.3 on the restoring torque, if permissible by legal requirements.

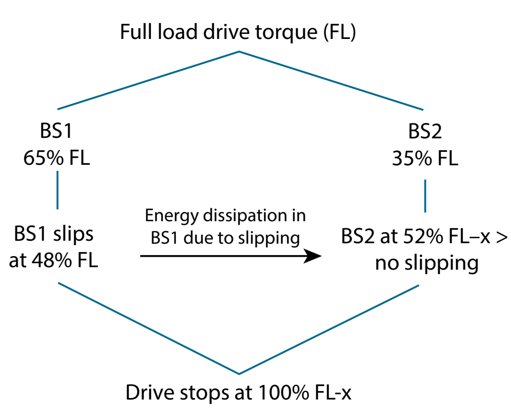
Safe Design of Load-Balancing Backstops

As well as the restoring torque, the design depends substantially on the efficiency factor in the conveyor system and the dynamic slipping torque of the stop that is set.

Example 1

Starting out from the assumption that:

- BS1 takes up 65% of the full load drive torque (FL) and BS2 35% of the FL
- The breakaway torque is set at 60% FL respectively
- The dynamic slipping torque is smaller than the static ($\mu_{dyn} = 0.8\ \mu_{stat}$), the following situation results:

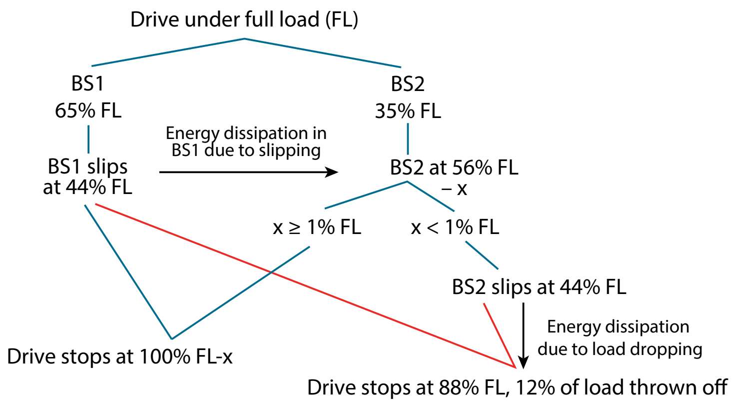


The efficiency in the belt system (x) basically has a positive effect, i.e. regardless of its specific value the overall belt will not slip.

The example makes it clear that the load balancing between two backstops on a common shaft can be optimized by means of torque limiters and that as a result, the components can possibly be designed smaller. However, a condition for this is a careful calculation using exact application data, as is to be recognized from the second example:

Example 2

The basic assumptions correspond to example 1 with the sole difference that the breakaway torque is set respectively at 55% FL. Depending on x (efficiency in the belt system), two possible scenarios result:



As already mentioned, the efficiency in the belt system (x) has a positive effect on the design of the backstop. The more precisely the efficiency x and the operating conditions are known, the more precisely the backstop can be designed. It is also possible to implement a smaller construction size. If this value is not known, Stieber recommends a safety factor of 1.3 on the return torque of the loaded belt, unless otherwise specified.

Each application naturally makes its own special demands, and the calculations for the design of backstops should always be carefully checked by experts who have experience with these solutions. Presupposing the relevant technical expertise, it is possible to specify cost-effective yet safe and reliable solutions.

Controlled Release

Electric motors are, in many cases, not designed to be capable of starting up with an overloaded conveyor belt. This would result in a severely oversized motor which would be inefficient in normal operation. In this case, the next step following a fully loaded stop is therefore the controlled unloading of the conveyor belt. How long this takes depends to a large extent on the type of backstop installed. Ideally, a backstop that is to be released mechanically or hydraulically permits a controlled release of the belt. In systems with more than one backstop, simultaneous and gradual release by means of a central hydraulic system is particularly efficient and convenient. This allows the conveyor to be run in reverse in a controlled manner and quickly unloaded.

One practical example is the case of a coal conveyor in a loading port. If the belt, fitted with a conventional backstop, stops following an interruption in the power supply , it must be unloaded before the system can start up again. This might take an entire day and incur huge costs due to interruption of scheduled docking times, among other things. A backstop with a release function, on the other hand, makes it possible to release the conveyor in minutes, so that loading of the vessel can then proceed according to plan.

Until now, most types of backstops, if they permit reverse running at all, do so to a limited extent, and certainly not at high speed. However, Stieber now offers products that no longer have this drawback. Operators of conveyor systems can now reduce stoppage times for belt unloading following a drive failure to a minimum.

While conventional backstops have plain bearings, type RDBK and RDBR backstops from Stieber have a patented roller bearing assembly. Thus they are able to run in reverse for a long time and most importantly, at high speeds.

Operational Trials and Statutory Regulation

The testing of backstops in operation is not currently prescribed, in part due to the cost and production downtime associated with this. On the other hand, backstops provide a key safety function and the application of a maintenance and testing program guaranteeing the reliable functioning of these components in an emergency seems more than justified.

With its countless mining businesses, Australia is a pioneer when it comes to operational standards for large conveying systems. The Australian machinery safety standard for belt conveyors for bulk materials AS/NZS 4024.3611:2015 describes the requirements for equipment widely used in mining, for example. Section 2.2.3.2[1] goes into detail about redundant design and component failure:

"2.2.3.2 Mechanisms for safeguarding against uncontrolled acceleration

Conveyor systems that can accelerate in an uncontrolled manner due to the effect of gravity must be equipped with mechanism(s) that automatically prevent such acceleration. Where a belt, a chain drive, a fluid coupling or a similar component is connected between motor and driven shaft, a mechanism must be installed to safeguard against uncontrolled acceleration, in order to prevent "bolting" if the interconnected component fails. On chain conveyors more than one such mechanism may be required.

If the failure of an acceleration safety device causes a risk to persons, uncontrolled acceleration must be prevented by two automatically responding mechanisms, wherein each of these mechanisms must be able to hold the entire load by themselves. These mechanisms must be monitored for wear and perfect operation. Each acceleration safety device must be designed so that it can stop and hold at least 150% of the maximum load of the conveyor system.

NOTE: Such mechanisms include brakes and backstops among other things."

In view of the greater attention paid to occupational health and safety, it cannot be ruled out that safety regulations in certain fields or regions are updated to the effect that regular checks of safety mechanisms under operating conditions are required. For example, it could be the case that the operator must execute an emergency stop situation of a fully loaded or even overloaded conveyor to check that the backstops and comparable components are functioning properly.

Even if operators can rest assured with a positive test result, they may still face the problem afterward that of their blocked conveyor system will have to be unloaded before production can be resumed. Anyone who has backstops that permit controlled reverse running in this situation can perhaps unload the belt and resume operation within minutes. In view of the cost of production downtimes, more and more operators are deciding in favor of such components.

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