FEATURE

Chains and Belts Play to Their Strengths

If it has to move — or be moved — (steel) chains and (synthetic) belts remain integral part of any motion system.

Jack McGuinn, Senior Editor

Belt or chain — which is an integrator to pick?

As with just about everything else in the manufacturing world — and all which that universe entails — it depends. After all, that's why the art of manufacturing is a *process* — not a one-system-fits-all discipline. Yes, once that process has been properly designed and correctly implemented for a given manufacturing production need, it may well run like the fastest, smoothest cookie-cutter-type operation ever devised.

"Process" suggests a system with a combination of parts, components, etc. The process is the end product of these things.

Two of these "things" are typically as important to that process as any other part, component or software suite — i.e. roller chain and synchronous belt technology. From straight-shot conveying systems to heavy-duty power transmission, or from clean-room-type production to oil field rigs — belt and chain drives are integral to their reliable operation.

As you might expect, there are significant differences between the two, with steel chains around since Samson was dating Delilah — thus owning the "mature technology" tag. Synthetic synchronous belts are the relative technological newcomer on the block, first appearing around the mid-1940s and more or less growing up with modern motion technology. As with many technologies, application — and cost — determine what goes where.

If you are a system integrator, it will typically fall to you to make that determination. How tough is it? We asked Nick Antonelli, senior engineer for Nordex Inc.

"In today's world there are many factors that influence the decision on whether to use belts vs. chain drives. Many of these factors were not as important or not even considered just a few years ago. Speeds, accuracy, safety, environmental and even noise factors now take a high prominence in the modern decision-making process — along with the age-old factors such as power, direction of rotation, how many axes are to be powered by the drive device, etc. Belts have improved a lot in recent years; so have chains and their method of lubrication. In our experience, we notice that belts are the preferred method in most modern applications for precision drives. The method of drive enters into the equation as soon as the driven axis is determined."

We put the same question to Chuck Briere, national sales manager for Peer Chain Company.

"Chain versus belt is the first thing a designer needs to consider," he says. "For a drive application in HVAC, V belts make sense. Belts are friction and can handle high speeds smoothly. Many air movement systems depend on high volume air flow." Briere adds that speeds of 3,600 RPM are better suited for belts. Also, the fact that belts are a friction technology means that in the event of an overload, belts will slip and avoid system damage.

"For applications in conveyor transmissions or to develop torque, chains make better sense," Briere says. "Conveyors are much slower—under 350 RPM on the driver. Chains can be used with a wide selection of sprocket ratios to help the designer achieve the desired speed. The demand for torque gives chains an advantage due to mechanical ratios and the need for a positive drive."

And, say Michael Hogan, senior roller chain design & applications engineer, and Eduardo Manta, roller chain design & applications engineer for U.S. Tsubaki Power Transmission LLC, "As a system integrator he may begin thinking about a chain at any time because it is so versatile and easy. Chains are excellent for a range of speeds and

Figure 1 A lumber mill roll case requiring careful synchronization and smooth operation for stacking of boards got what it needed from Gates Corp.'s poly chain GT carbon extended length belt (courtesy Gates Corp.).

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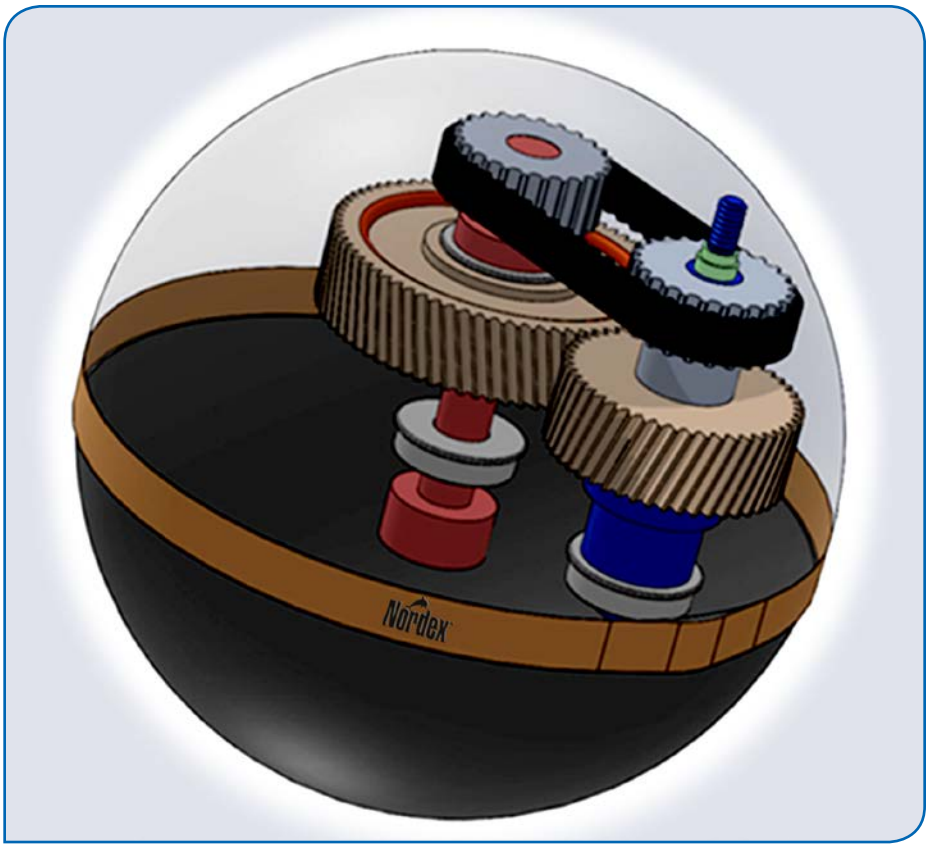

Figure 2 Illustration of synchronous belt assembly (courtesy Nordex Inc).

loads, plus chain length is easy to adjust by specifying the number of links required.

"The chain selection process is fairly straightforward. Key things to know are horsepower, RPM, intensity of shock load, temperature and exposure to potential corrosive conditions. A wide assortment of carbon steel chains, Lambda self-lube chains, Titan long life, Neptune corrosion-resistant, coated carbon steel, and stainless steel can be considered. The selection procedure quickly guides to the correct chain size."

We mentioned cleanroom, FDA-type applications where motion technology is required — steel or plastic? Both have their faults, as Nordex's Antonelli explains.

"For chain applications, the driving factor may be what temperature the device is in, or a requirement that no lubrication be used. Modern chains can be permanently coated/impregnated with a "dry" lubricant that inhibits wear and can eliminate the possibility of the lubricant contaminating the cleanroom. Rubber-style belts tend to flake and leave rubber shavings. There are new classes of "FDA" belts that reduce this flaking effect by a factor of 75%."

Taylor Jung, product line manager, synchronous drives, Industrial Power Transmission N.A for the Gates Corporation, concurs — followed by one critical difference. "Both belts and chains will produce some sort of contaminant during their operation. Chains have grease, oil, and metal particulates. Belts will shed material over time as well. Neither is a perfect solution. The primary differentiation between the two is in maintenance. Chains require routine lubrication and more frequent replacement. In wash-down environments, the potential for spread of grease and oil contamination is elevated and the maintenance requirements skyrocket. Polyurethane synchronous belts do not have any of these concerns and are a significant advantage in food handling environments."

Peer's Briere counters with the fact that "Roller chain in 304 material or a 600 stainless can now be manufactured with solid roller and solid bushing. Having no seam in any of the round parts is great for disinfecting

or cleaning without crevices for bacteria to grow. The solid bushing provides increased bearing area to spread and distribute the bearing load. Less stretch with solid bushing opposed to split bushing. Belts have a difficult time operating in wet caustic environments when wash-downs are required by FDA."

And at Tsubaki, clean-type, no-lube applications are still in play due to a patented steel chain. Say Hogan & Manta: "Our Lambda chain has an extended, longer wear life than our standard. Our chain is lube-free thanks to our oil-impregnated bushings, which not only helps minimize elongation, but also reduces downtime and maintenance operation cost. (The) chain is ideal for those applications where lubrication is impractical or impossible. Lambda has the same maximum allowable load as our standard roller chain. For applications with VOC limitations, chains with no lubrication, dry lubrication (Molykote), or plated pins can be considered."

Briere points out that, "If heat is involved, then stainless is a must to transmit power, convey or lift. If there is an extreme, abrasive element, chains can be hardened to survive in the tough environment. A great example would be cement and limestone (mills)."

Antonelli cautions that just any steel will not work in certain applications; homework must be done; choices must be made. Remember — this is a *process*.

"When talking about steel in general it is important to define which type of steel is being used," says Antonelli. "Standard-coated steel chain typically does not stand up well to certain environments such as sewage treatment plants and salt-water locations; stainless steel and alloy chains offer a possibility to overcome these issues. Also, when sludge or solids are a factor, belts would tend to clog or entrap the contaminating material, especially if a wide belt would be used. The open design of chains allow for the 'release' of such contaminates and make chains more forgiving than belts in those types of applications."

But when talking harsh environment, Jung reminds, "That depends on your definition (of harsh)," he says. "On one hand, if you have very high temperatures, chain is likely the best option. If caustic chemicals are present in the environment, then polyurethane synchronous belts will perform much better. It is a situation-dependent answer."

But if it's steel — or titanium — you require, Tsubaki, as do all the suppliers mentioned here, offers choices. "We typically suggest using stainless steel chain for any extremely harsh environment where extreme temperatures or corrosive chemicals are encountered," say Hogan & Manta. "Different grades are available, depending on the exact environment, including our 600 series, SS 304 stainless, NS 316 stainless steel, TI titanium series — and even PC plastic/steel combination chains.

"Stainless steel generally has one drawback: load capacity. Neptune Chain, which has a special triple coating "galvanic" type coating over our carbon steel chain, provides corrosion protection and has the same performance rating as our standard carbon chain."

We wondered: Are there any advantages of one (belts) over the other (chain) regarding use with the latest NEMA Premium motors? Or AC- vs. DC-drive type motor systems, for example? Are there any other performance differences between the two regarding motor-type compatibilities?

"Historically," says Nordex's Antonelli, "AC drives have tended to be more rugged and cost-efficient — especially in higher power applications — while

> *"Synchronous belt technology has more potential for innovation and its capabilities will grow faster than chain, leading to a perpetual, if ever narrowing market. The capability of carbon fiber tensile cords has not yet been fully explored."*
>
> **Taylor Jung,** Gates Corp.

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DC drives have tended to be the choice where high repeatability and positioning are concerned. This is especially true in reverse rotation and positioning applications. There are constant improvements in motors and control technology, so the line dividing AC and DC applications is tending to blur."

Hogan & Manta explain that "Chains are used in very precision-oriented robotics — often used for electronics or automation applications. Tsubaki offers bearing-bush chains which have a very exacting pitch tolerance; users can often set precision accuracy close to .005". (Our) bearing bush chain virtually eliminates initial stretch; with needle bearings placed between the pin and bushing, bearing bush chain offers excellent wear life without lubrication. Major dimensions of the chain and attachments are the same as our ASME/ANSI-standard, double-pitch conveyor chains; (it) works perfectly with standard, over-sized roller sprockets."

We then had a thought — is there ever a scenario in which both — steel and fabricated — are used in tandem?

"A systems integrator will opt for a belt/chain drive if it eliminates the need for another drive motor," says Bob Eisele, of Amacoil Inc. The traverse unit (see diagram) rides on a shaft that is belted to the main motor.

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If a separate drive motor was used to power the traverse, then electronic controls would be needed to synchronize the linear movement of the traverse with the rotational movement of the spool. Using the belt or chain to link the traverse driveshaft to the main shaft eliminates the need for another motor — saving time and money."

Similarly, are there applications where, at the end of the day, either one is equally acceptable in both performance and total cost? We started with Antonelli.

"Interesting question; my take on it would be any application where there are few controlling factor constraints. One trend we are noticing lately is the elimination of belts/chains/gears altogether by going to a direct-drive system. This is where the motor is driving the axis directly. This has cost, complexity and reliability benefits."

Jung offers that "While there are certain situations where both technologies have their advantages, the majority of drives would perform better and have a lower total cost of ownership with synchronous belts. This is because they do not require any regular main-

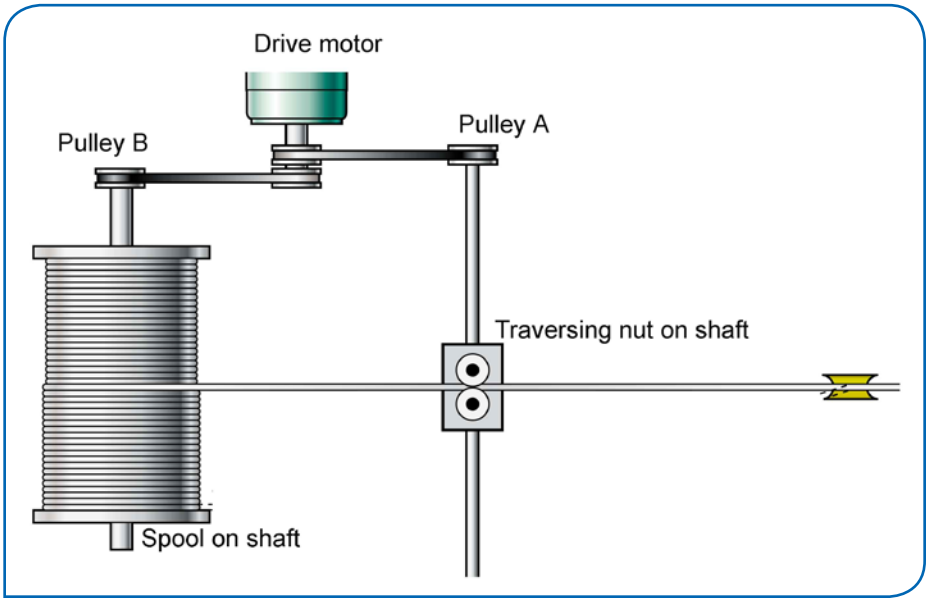

Figure 3 Note that traverse unit rides on a shaft that is belted to the main motor. If a separate drive motor was used to power the traverse, then electronic controls would be needed to synchronize the linear movement of the traverse with the rotational movement of the spool. Using the belt or chain to link the traverse drive shaft to the main shaft eliminates the need for another motor saving time and money (courtesy Amacoil).

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Nick Antonelli, senior engineer, Nordex, Inc.

tenance and last longer than chain."

Another key consideration regarding belts/puller chains — width matters—for various reasons. Once upon a time, steel ruled in this regard. Things change.

"A wider belt may exhibit more frictional losses than a narrower belt," says Antonelli. "This effect is more pronounced if the belt in question tends to track to one side or the other. A wider belt typically tracks with more force than a narrower belt. A wider or multiple chain set-up may have an issue wear the individual chain strands or segments stretch at different rates and the different strands may not see the same loads."

Peer's Briere states that "Belts as friction drives are limited in ratio selection and to transmit higher horsepower increases the overall size due to the need for more surface/friction. Tooth belts simply do not have the ratio selection and are limited in center distance choices. Chains, on the other hand, are extremely flexible for machine design due to the ability to use almost any center distance and allow higher horsepower to be transmitted in smaller envelope dimensions."

Gates' Jung: "As a general statement, the best belt technology has been able to match chain widths for over 10 years. With either product, appropriate drive design is of key importance for long term performance. Under-design has its obvious resulting failures, but overdesign can result in premature failure as well, both of the belt and connected equipment." And Tsubaki's Hogan & Manta explain: "On a chain, increasing the width (multi-strand) will increase the chain's working load and the average tensile strength, while keeping sprocket diameters small. In general, for a given width, chain can often be narrower than belts for a given RPM and power requirement."

There's more to this part of the design process than we currently have space for — we haven't even touched upon things like software, bearings integration; ease-of-replacement; lifetimes…

Be we've left space for a bit of crystal ball gazing — e.g., belts, chains, glasses half-empty, half-full, etc.

"Chains have a future in the applications that I have mentioned in the questions above," says Jung. "Synchronous belt technology has more potential for innovation and its capabilities will grow faster than chain, leading to a perpetual, if ever narrowing market. The capability of carbon fiber tensile cords has not yet been fully explored. All of the surrounding belt components continue to be improved in order to fully utilize the strength of the carbon fiber cord. I don't feel that it is possible to identify the limits of the technology at this time."

But men of steel — fear not.

Says Peer Chain's Briere on whether there is a future for roller chain-type drive applications:

"There will always be a need for a positive drive." **PTE**

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