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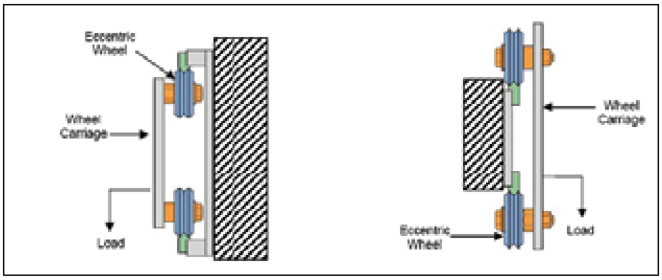

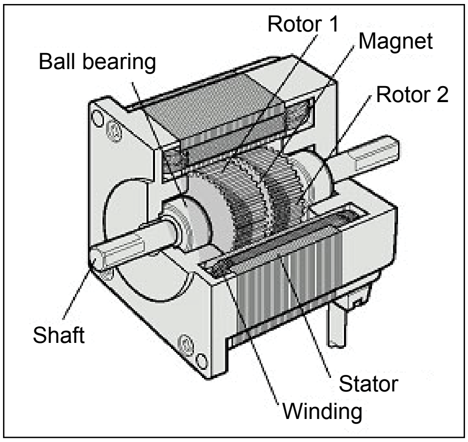

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Slashing Operating Costs Of Low-Profile Conveyors

Charles Mitchell, President,
Conveyor Technologies LTD.

(Editor's Note: Follow-up questions put to Tony Mitchell, Conveyor Technologies vice president of sales, immediately follow.)

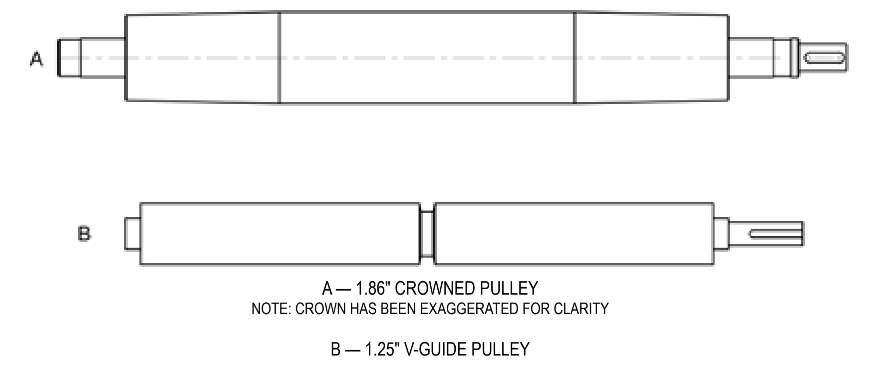


Figure 1—As pulley width increases, a 1.25"-diameter pulley will deflect nearly five times more than a 1.86"-diameter pulley; this effect is compounded when the pulley is weakened with a V-groove.

Figure 2—A tool-less, swing-up tail pulley provides one-minute belt exchange while retaining the tension setting. Calibrations on both sides permit rapid, precise balanced tension by which each increment represents the tension-setting-per-foot of conveyor length.

Introduction

Low-profile conveyors are ubiquitous in industry, serving key roles in the production and assembly of everything from cosmetics to snacks; beverages to electronics; and land transportation. Broadly speaking, we're talking about compact belt conveyors with one- to two-inch pulley diameters and maximum belt widths of 24 inches. Typically used in 24/7 applications in packaging, assembly, labeling, inspection and sorting, low-profile conveyors form critical production links where unplanned downtime or time-consuming maintenance is intolerable. Upstream equipment, such as ovens, bottlers, extruders and pasteurizers continue to churn out product, so line stoppages—planned or unplanned—must be minimized.

Certainly the most critical areas of low-profile conveyors that draw maintenance attention are the belt itself and the pulley/bearing system. Speed, load, accumulation and inclined operation increase forces on these components, as well as the drive system, highlighting problem areas such as belt tension. Belt manufacturers universally cite correct belt tension and crowned pulleys as keys to long belt life and consistent, slip-free performance with positive self-tracking. Incorrect belt tension is responsible for a high percentage of component-related failures and maintenance cost. Whether over- or under-tensioned, incorrect belt tension can cause a variety of problems, including bearing overload, mistracking, belt slippage and accelerated component deterioration.

What do Belting Manufacturers Recommend?

Correct tension varies, but typically it will be one mm of belt stretch per foot of conveyor length. However, with allowable manufacturing tolerances on belts, a belt will normally be a little longer or shorter than its stated size. To ensure correct tensioning, a simple system has been developed to allow maintenance people—and even novice operators—to set correct tension in seconds. The system uses the tail pulley to set tension; once all belt slack is taken up, tension is set via a scale on each side of the conveyor where each increment represents the tension-setting-per-foot of conveyor length. It seems counterintuitive, but a belt that is under-tensioned can actually elongate in use, which leads to many belts in good condition being discarded, due to a conveyor's limited tensioning capacity.

Again, following the recommendations of the world's major belt manufacturers, a crowned pulley with a correctly tensioned belt is the preferred way to achieve automatic belt centering. A crowned pulley produces dual, lateral opposing belt forces that balance each other when the belt is centered over the crown. If the belt moves off center, these lateral opposing forces become unbalanced, resulting in the "higher-force" side directing the belt back to its centered position. This action provides virtually wear-free centering. Crowned pulley systems also allow higher accelerations and speeds with much less belt and component wear.

Properly tensioned belts on crowned pulleys easily withstand moderate short-term lateral forces without major displacement from center. When side loads increase, a V-retainer on the underside of the belt can be added to limit off-center drift. The V-shaped profile rides in a groove cut into the pulleys (that reduces pulley rigidity), and a groove running the length of the conveyor bed. This approach allows the crowned pulley to quickly center the belt when the external force is removed, thus minimizing wear on the V-retainer. Belting manufacturers recommend that V-retainers should not be the primary belt tracking system, due to the high wear the V-profile incurs. If the lateral force is sufficient, the V-retainer will climb out of its groove and may damage the belt. An alternative is to use the V-retainer on the top edge-surface of the belt and have it guided and constrained from the top down by a rolling Delrin V-guide, located opposite the point where the belt experiences side forces. These guides keep the V-profile fully constrained and with reduced wear. A normal V-retainer alone offers no true "non-contact guiding" so it tends to drag against the sides of the groove and constantly wear. Another point to consider on a bottom-mounted V-retainer is that the weld used to attach it results in a slight high spot in the middle of the belt, which can be troublesome if the belt carries small products that are tip-over prone. Because of material incompatibilities, the V-profile cannot be used with certain types of belts, such as silicon-based, Teflon and polypropylene.

Pulley Diameter: Size Matters

Low-profile conveyor pulleys normally range from 1- to 2-inches in diameter, but this small range can produce a surprising difference in conveyor capacity and performance, as well as in belt, cleat and bearing life. Smaller-diameter pulleys may be needed for applications requiring a minimum height profile where speeds and loads are moderate. However, logic dictates that a smaller-diameter drive pulley will have a much greater tendency to

continued

deflect as the conveyor width increases (a 1.25" pulley without a V-groove will deflect nearly five times more than a 1.86" pulley with the same load). This creates an inherent "traction" disadvantage for load-carrying purposes and can negate the crowning effect (belt-centering capability) of the pulley. This is highly problematic in applications that involve reversing, wider conveyors and accumulating or inclined operation. Flexing a belt over a smaller diameter also accelerates the breakdown of the belt structure, leading to erratic operation and shorter life.

When scaled up in width, conveyors with small-diameter pulleys often cannot carry proportionally greater loads. For example, a conveyor with a pulley diameter of approximately 2 inches, with a correctly tensioned belt, will carry twice the load at a 24-inch width than it does at a 12-inch width. But this rule of thumb does not hold, as pulley diameters approach the 1.25-inch range (see chart).

Smaller pulley diameters—with their greater tendency to deflect—have limited ability to produce the proper belt tension needed to achieve automatic centering with a crowned pulley. The resulting loss of "traction" and self-centering are sometimes compensated for by lagging or knurling the pulley and substituting a longitudinal V-retainer—rather than a crowned pulley—for belt centering. Because the pulley must now have a V-groove in its center—as well as being knurled—its rigidity is further compromised. Indeed, belt manufacturers discourage knurled pulleys because they invariably abrade the belt underside and resist tracking—leading to a substantial reduction in belt life. Impacted debris in the pulley knurl, or worn knurling, can lead to belt slippage and mistracking, as well as accelerated belt, V-retainer and pulley knurl wear. Abrasion can occur without any load on the conveyor or increases of belt speed. Debris from this abrasion may be unacceptable in food, pharmaceutical or clean-room applications. And routine cleaning of the knurling is impractical because it requires stopping production and removing the belt.

Bearing life is also greatly affected by pulley diameter. A one-inch pulley must run at twice the rpm of a two-inch-diameter pulley to produce an identical belt speed. Small pulley diameters can result in smaller bearings with lower load capacity running at higher speeds, thus reducing service life. Ensuring that the bearing outer race cannot rotate in the bearing plate housing can improve bearing performance and avoid the need to replace worn bearing housings.

Drives are available in a wide variety of styles. One style that is gaining popularity is the external shaft-mounted design. This unit is compact, provides "perfect alignment" and eliminates all couplings, drive belts, chain, sprockets, guards and tensioning. These drives can be radially positioned in 30-degree increments. Mounting of this drive allows an exchange in less than five minutes when equipped with an optional plug connector.

If a conveyor is used for multiple applications that can be run at lower speeds, a variable speed drive may be desirable. This reduces wear and power consumption and provides optimum speed for each application.

The service manual for a conveyor can provide clues to potential failure issues; sections on preventive maintenance and troubleshooting can be enlightening. For example, does the manual recommend stocking spare pulleys, bearings and bearing plates, or disassembling and checking bearings during a belt change or cleaning knurled pulleys? Belt change time should be based on the conveyor in its operating position, not resting on a bench.

Manufacturers offer a broad range of options, such as cantilever stands, tool-less guide rail removal, belt support removal and belt release that can permit a tool-less, "one minute" belt change on a stand-mounted conveyor. These options should be reviewed with the manufacturer—especially if downtime is a critical factor.

Follow-Up Questions for Tony Mitchell, Conveyor Tech Vice President of Sales

PTE. Are there any advancements on the horizon in the material composition of drive belts that would enhance their durability?

TM. I am not aware of any new advancements in belting composition that would drastically impact the low-profile conveyor. Pulley diameter has a major influence on belt life since a larger pulley decreases belt fatigue and

continued

permits a heavier, broader belt selection. Conveyor Technologies Ltd. has customers running daily production without having replaced belts, pulleys, bearings and bearing housings in 10 years.

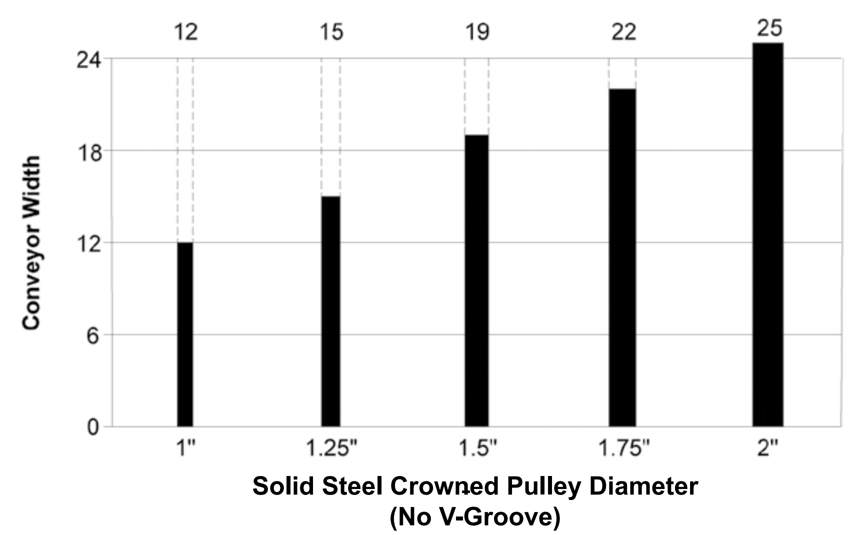
PTE. Why—unless it is simply continual human error—do conveyor system users have so much trouble in maintaining the proper tension for running their lines? Wouldn't on-the-job experience come into play?

TM. The primary reason that proper belt tension is such a major problem area is that until Conveyor Technologies Ltd. appeared, no one offered a precise method for tensioning that considered belt manufacturers' recommended tension value, conveyor length, manufacturing tolerance, or if stretching has occurred. (For example), a well-known low-profile conveyor manufacturer's service manual dealing with tensioning does not address these issues. Because the service manual does not define "proper tensioning," it is difficult to know if it has been achieved when their procedure is complete. Another major producer also assumes the belt length is correct and ignores the same issues. This system also does not provide assurance that the correct tension has been achieved. There is little wonder that conveyor users are often compelled to increase belt tension to achieve a functioning conveyor—and live with a higher maintenance cost.

PTE. If one-inch pulleys are so problematic vs. 2-inch pulleys, why do companies use them?

TM. With the advent of the Vee guide for belt tracking, most one-inch pulley designs converted to 1.25"–1.375"diameter. While this provided a slight reduction in pulley rpm, it does little to improve tensioning because of the Vee groove. This 1.25" diameter still retains a reduced belt and bearing life, along with a low-tension capability on wider

Table 1—Pulley Diameter vs. Recommended Maximum Conveyor Width Using 8-Class 8 N/mm Belting.



This chart—based on data from a leading belt manufacturer—illustrates how conveyor width can be limited by pulley diameter. This represents belting commonly utilized on low-profile conveyors. The belt rating is 8 N/mm, using a minimum recommended tension of 0.3 percent to ensure automatic belt tracking. The data provide a technical approach to pulley selection that will assist in achieving optimal performance of conveyor and belting—and lower operating cost. *(Caution: The belting manufacturer notes that use of a V-groove for restraining the belt will have a negative effect on chart values, thus voiding the chart data for this type of pulley.)*

units. Why these manufacturers hesitate to convert to 1.875"–2.00" diameters—which could have a positive effect on performance and component durability—is debatable. It would certainly have a negative effect on production costs and replacement part income. The benefit to the customer, however, in terms of maintenance costs and production down time, can be tremendous.

PTE. Is bearing *material quality* a contributing issue regarding their lifespan in these systems, or is it simply a size vs. outer race and plate housing issue?

TM. Because most low-profile conveyors require the belt top to be the highest surface, the pulley diameter controls the maximum bearing size. Consequently, the smaller the pulley diameter, the smaller the bearing.

For more information:

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tony@conveyortechltd.com

Baldor Grid-Lign Couplings

ELIMINATE PREVENTIVE MAINTENANCE

Baldor Electric Company introduces the Baldor-Dodge pre-lubricated Grid-Lign coupling, a maintenance-free, lubed-for-life design that eliminates the time and expense associated with preventive maintenance. Interchangeable with existing grids, hubs and covers, this product is easy to install with no mess, and eliminates unexpected down-time associated with improper coupling lubrication.

The unique, environmentally friendly design of the pre-lubricated Grid-Lign coupling features high-performance synthetic oil impregnated into a polymer shell that encapsulates the grid element. This polymer shell allows for efficient, long-lasting lubrication throughout the life of the coupling. The polymer acts as a reservoir for the oil that prevents contamination during installation and avoids the mess required with greasing a traditional grid design.

continued

product news

The coupling not only includes the optimal amount of lubrication for the life of the element, but the synthetic oil used actually improves the lubricating performance of the grid segment during operation. Baldor-Dodge prelubricated Grid-Lign coupling components are interchangeable with competitive tapered-style grid couplings. Interchangeability includes use with complete vertically or horizontally split covers and half or full spacers.

For more information:

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Nook

EXAMINES
FUTURE OF POSITION CONTROL

Nook Industries, a linear motion control systems and components manufacturer, has recently introduced its patent-pending Nook Sensor System (NSS). This system has been developed to provide precision position control for translating screw jack systems. With a highly accurate repeatability of up to + .004" (0.1 mm), the NSS is designed specifically for the ActionJac and is unique to the screw jack world in its simplicity of design, which features a custom aluminum stem cover. This cylindrical stem cover provides a housing shroud for select position and travel limit sensors, which are mounted with custom profiles and used to detect ring magnets fixed to the translating screw. A patented, state-of-the-art electronic magnetic circuit is the basis of operation for these sensors. The sensors on the NSS are manufactured using a polypropylene over-molding technology,

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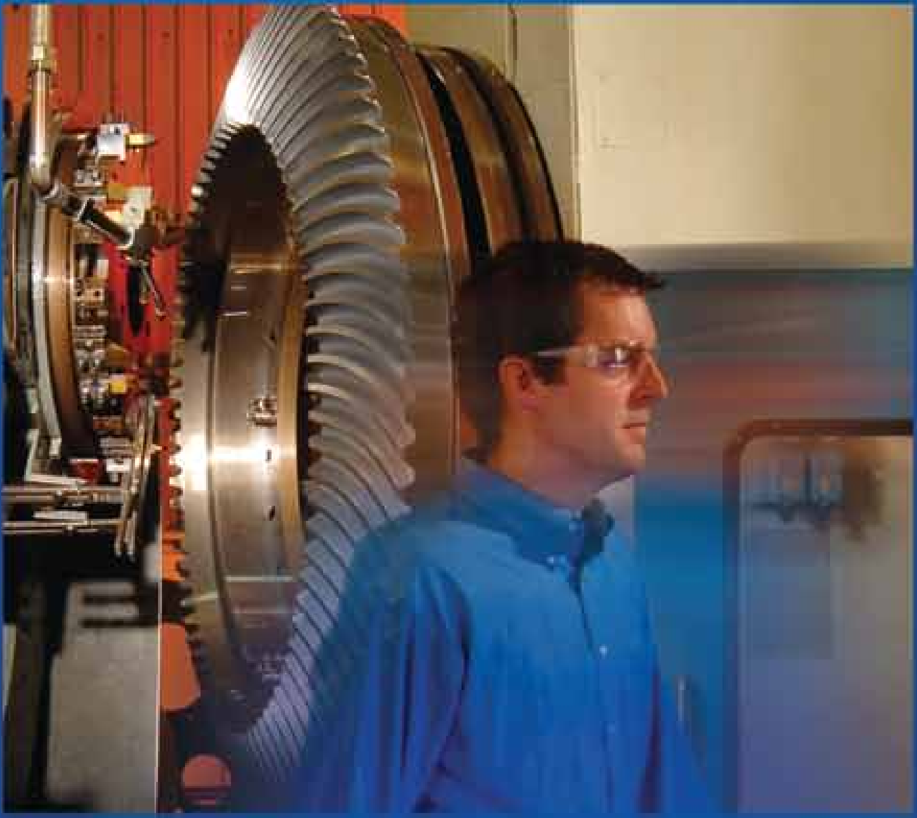

which allows the sensor to be completely sealed into small sizes without compromising durability. An unlimited number of sensors can be added to meet a wide range of position sensing requirements as configurations with Nook's ActionJac are only restricted by the stem cover length. The cost efficient NSS replaces higher cost rotary limit switches as its simple aluminum stem housing design adds the functionality of position sensing versus traditional steel stem covers. The ease-of-use design can be incorporated to meet a myriad of industrial applications including; material handling, defense, aerospace, medical devices, stamping, conveying and sorting.

For more information:

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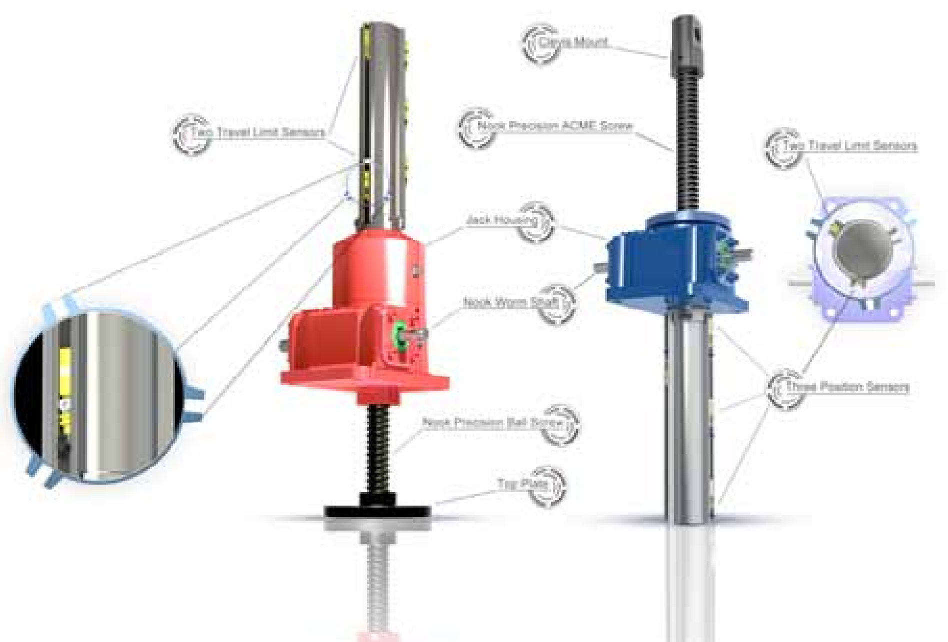

Gates

OFFERS BELT DRIVE SYSTEM SOLUTIONS

From system design and component selection to prototyping and delivery, design engineers are charged with ensuring efficiency, hitting cost targets and delivering systems that perform. In a recent project to design a human-powered boat that could withstand a 3,000-mile ocean crossing, Gates was called in to review the design and offer key component recommendations.

After devising a plan to pedal across the Atlantic and raise $250,000 for charity, two young engineers from the U.K. named Mark Byass and Mike Sayer enlisted a team of experts in boat design, fiber usage, ergonomics and hydrodynamics to design the watercraft. It's called Torpedalo.

Gates product application engineer Dan Parsons reviewed the designs and made key recommendations—eliminate

continued

the gearbox and use narrower belts in each of the two stages, making the system lighter, simpler and more efficient. Each stage of the synchronous belt drive is ~98 percent efficient, for a total estimated drive system efficiency of 96 percent. That means a smoother ride for the crew. This process was developed using *Gates Design Flex Pro* software, a design program that helps design engineers, maintenance engineers and power transmission distributors find solutions to fit the parameters of their belt drive systems. In addition to providing a fast, accurate way to design two-point drives from scratch, it allows you to:

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- Estimate the cost savings of replacing roller chain with a Poly Chain GT belt drive
- Compare noise levels of various Gates synchronous belt drives

Design Flex Web, the program's online counterpart, offers all of the functionality of *Design Flex Pro* plus easy access from your browser. For multi-point or complex serpentine belt drives, customers can utilize *Design IQ* software.

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Stober

INTRODUCES HELICAL BEVEL GEAR UNIT

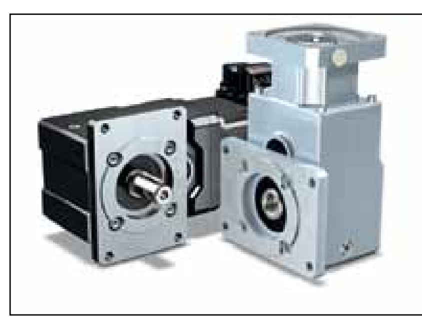
Stober Drives, Inc. has developed a new KL helical bevel gear unit, a compact right-angle drive that meets the packaging manufacturing industry's latest machine requirements. The space-saving gear reducer comes in sizes 1 and 2, and is suitable for packaging, filling, conveying, general automation and wash-down, said Stober product manager Adam Mellenkamp.

When compared with the conventional Stober K1 helical bevel gear unit version, the new KL1 supplies increased torque density of well over 100 percent. "Some packaging machines are very small, so we created the KL, which is the smallest size we have today," says Mellenkamp. "It's essentially a four-inch cube that fits in your hand."

Development of the KL is part of Stober's desire to make the manufacturing industry more efficient and productive—and green. "As we rebuild U.S. manufacturing and create jobs, productivity is the key to competing against low wage labor markets," said Peter Feil, vice president at Stober. "Highly productive and efficient equipment saves money, energy, materials, and time."

Helical gearing helps manufacturing go green by preventing breakdowns, saving energy and landfill space and greatly improving the bottom line in U.S. factories, he added.

"Going green in manufacturing is no longer an optional, feel-good choice," Feil said. "It is sound business



and our opportunity to regain our competitive edge in the global economy."

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A CASE FOR
Large-Scale Manufacturing

BIG COMPONENTS AIM TO REVIVE NORTH AMERICAN INDUSTRIAL MARKET

Matthew Jaster, Associate Editor

Brad Foote Gear Works has been building precision gears since 1924 for industrial markets as diverse as oil and natural gas, mining, steel, transportation and power generation (courtesy of Brad Foote).

It's no great secret that the United States has lost a bit of its industrial mojo. This country's manufacturing complex once played a decisive role in the outcome of World War II, helped create a vibrant middle class and basked in all the glory of real economic expansion in the 1940s–1950s. Through the years, however, it seems that manufacturing ingenuity has been systematically replaced by a cubicle culture where information, bio-technology and service trump everything else. Thankfully, North America is still in the business of making *stuff*; the kind of *stuff* you need to run wind turbines, agricultural equipment, steel mills and transportation projects. The secret to a good, "ole-fashioned" industrial renaissance might just be found in the manufacturing operations that are currently supplying large power transmission components to the alternative energy, steel, off-highway/construction, oil and gas markets.

Tim Carpenter, vice president and general manager, Rexnord Global Gear and Services Groups, thinks the U.S. large-scale manufacturing base has the capacity and capability to be globally competitive. "Many operations started making this move in the 1980s and several are very successful today. The implementation of lean and Six Sigma—not only in the operations but equally in the office—have allowed many businesses like ours to not only compete but be world class."

Carpenter believes that the U.S. still has a remarkable advantage over global competitors thanks to its experience, knowledge and knowhow and the existing base of equipment and skilled labor that sets it apart from other regions. "Companies that are investing in continuous improvements have the ability to compete in engineered /non-commodity production," Carpenter says. "The same can be said for much of Europe, provided their input costs can be managed."

For Sergio Gamboa, sales director at Brad Foote Gear Works, a Broadwind Energy company, the U.S. manufacturing base simply has to be faster, smarter and more productive than the competition. "Europe and Asia will always be a part of the landscape. What we really need to do is supply what the competition can't. We have to provide a better service to our domestic suppliers and customers with good parts, on-time, at a level that the foreign competition can't match."

In Canada, quality and skilled labor are two areas where large-scale manufacturing companies thrive. "We have had Chinese companies approach us because they cannot find the quality in the final product that they require," says David Manders, technical sales representative, Vancouver Gear Works. "North American materials and our skilled labor are hard to beat, and that is recognized by many foreign markets. Other nations, however, are catching up, and we need to squeeze out all the manufacturing efficiencies that we possibly can to remain globally competitive."

From De-Industrialization to Re-Industrialization

A wind energy strategist recently suggested at an alternative energy summit that de-industrialization has plagued heavy industrial, large-scale manufacturing in North America since the 1970s and will negatively impact this segment in the future. While there's no arguing manufacturing isn't what it used to be, Pat McGibbon, vice president of strategic information and research at the Association for Manufacturing Technology (AMT), believes both the perception and reality regarding North American manufacturing is changing."

"History has shown that the North American manufacturing sector is very resilient. We were far behind in the 1980s, had a phenomenal period from 1992–1998, and in the last decade we've pushed manufacturing technology up another notch. North American companies are bringing new products and innovations to the table that didn't exist five years ago. I would argue that we've had slow periods as well as periods of significant, substantial growth."

Manufacturers that produce gears, bearings and couplings feel the same way.

"There is no doubt there has been a 'de-industrialization' in the United States since the 1970s. This is an irrefutable fact," Carpenter at Rexnord says. "However, much of what moved was not large-scale, highly engineered, mission-critical industrial equipment—and that is our business. For smart companies that have invested wisely over that same period, the core of the business gain remains and thrives in the U.S. while competing globally."

When the wind energy industry started taking off, Brad Foote became one of the leaders in the market. "We moved away from other industries at that time and followed the transformation into wind until it leveled off in 2008–2009," Gamboa says. "Today, we are a much more diverse company serving multiple industries. In the future, we will service all the industries that require coarse pitch gearing, all sectors on a high and low volume scale."

"The de-industrialization taking place in the United States is a problem that we also face here in Canada," Manders says. "With a hard-nosed determination to make everything as low a cost as possible, we as a society have proactively chased heavy industry to foreign markets where you can get forty workers for the price of one North American skilled tradesperson. We have chosen a disposable lifestyle which accepts second or even third rate products simply because they are cheap, but in reality, one well made product would be cheaper in the long run."

The difference between a world-class manufacturer and a run-of-the-mill manufacturing outfit might simply come down to the investments made in new technology. It's in this area where North American manufacturers can excel in the global market.

"Technology will continue to allow for continuous improvements in through-

continued

Rexnord is one of the few companies in the world that offers gear casting, in-house heat treating and carburizing, sophisticated gear cutting and precision grinding at a single location (courtesy of Rexnord).

Given the length of time that large-scale manufacturing takes, any minor advances in technology can have major impacts in manufacturing times (courtesy of Vancouver Gear Works).

put, cycle time reduction and cost out. It will also afford improved performance in our end products through higher quality parts," Carpenter says. "Near term advancements will address throughput and increased quality while mid-term to longer term advancements will afford us the options of manufacturing products in entirely new ways. New breakthroughs—at least for us—will come from heat treat and machining."

Gamboa notes that Brad Foote's success is largely based on its machine technology investments. "In order to be a premier supplier of high quality bevel gears, we've made technology investments for the sole purpose of driving down costs and saving valuable time on the manufacturing floor. In the future, multi-axis machining centers will play a large role in decreasing cycle times and lowering costs."

"Given the length of time that large-scale manufacturing takes, any minor advances in technology can have major impacts in manufacturing times. It seems that more and more machines are coming out with gear cutting as part of the machine options. Being able to turn, mill, drill and machine the teeth in one setup improves the quality and costing," Manders adds.

Meeting Large-Scale Expectations

If there's a common thread to be found between companies that produce big gears, bearings and couplings, it's the engineering, design, safety, maintenance and technology requirements needed for these large-scale power transmission components. These components come prepackaged with challenges including delivery expectations, global competitiveness, raw material shortages and education/training obstacles.

"Our greatest challenge is meeting the delivery expectations in the large gear market. It really does not want to hold inventory," Gamboa says. "Brad Foote is meeting raw and finished goods inventory levels with improved communication with our customers as well as a very good process flow."

"In the supply chain, it is critical that companies spend time and money investing in their own associates but equally in their suppliers. Partnering is more critical now than ever before," Carpenter says. "Being globally competitive is a huge undertaking but it often starts by leveraging what made a company successful to start with."

While the skilled workforce in North America is stronger than most areas around the world, it's still nowhere near what it needs to be for future success in manufacturing. "I travel to our customers and end users and the message is unanimous—it's education," Gamboa says. "Training of our human resources is important, but there's also a growing demand that can't be met because of a lack of training and education on the shop floor. Actually it's gotten worse in the last couple of years; not a lot of people would like to run a machine. They'd be much happier sitting behind a desk. If we really want to change the manufacturing perception, it starts here."

"Many foreign companies are using the exact same machinery that we take pride in housing. The difference is that they do not have the skilled labor to operate it the way we do," Manders says. "Our governments need to be proactively promoting the skilled trades in North America. We cannot afford to lose the knowledge that we currently take for granted and expect to keep offering superior products."

Not only must skilled labor requirements be met; the access to market data and analysis needs to be more readily available to certain segments of the manufacturing industry. "I think an organization like AGMA would play a vital role in gathering *clean data* to help us make logical business decisions in the gear industry," Gamboa says. "I'm sure Europe and Asia currently do a much better job. We need more of the gear industry to get involved and get the material from a single source."

"Given the relatively small size of the large-scale manufacturing community in North America, we need to work together sharing industry knowledge through forums such as AGMA and other industry-based groups. The old adage, 'Together we are strong…' comes to mind," Manders adds.

Despite these challenges AMT's McGibbon thinks North America is neck-and-neck with Japan and Europe regarding technology, cost structure and meeting these various manufacturing demands. "The Germans have a slight advantage in heavy components because they have closer access to Central Europe and Russia where the foundry regulations are not as strict as they are here. They also have an education system that provides an excellent labor force geared toward quality and accuracy. In Japan, it's all about making costs disappear. The U.S. excels at the process engineering side. From a manufacturing technology perspective, Europe, Japan and the United States should have control of this market segment for many years to come."

AMT's Manufacturing Mandate is trying to assist where it can by focusing on global regulations and cost structures, R&D opportunities and building a stronger, educated and trained workforce. "It all comes down to taxes, labor supply, regulations and the overall image of manufacturing today," McGibbon says. "I think North America has made significant improvements in all these areas in the last four years."

Expanding North American Infrastructure

Politicians and economists have been pushing for more emphasis on North American infrastructure projects recently. Since the end of the economic downturn, the focus has been on alternative energy, bridges, tunnels, mining and heavy equipment projects. If these projects come to fruition, it would not only benefit the manufacturing community; it may also take a bite out of the unemployment rate. Are a significant number of these projects already under way, and if so, what real effect will they have on power transmission component manufacturers?

Extensive precision form tooth grinding capabilities to 160" diameter and AGMA Q15—including the largest internal/external form grinder in the U.S.—have helped to establish Brad Foote Gear Works as a leader in large gearing (courtesy of Brad Foote).

"Infrastructure development projects have been active in the quoting stage. Much of the funding, though, has not reached the contractors and thus not reached the manufacturers," Carpenter says. "Alternative energy spending (wind, solar and hydro) appears to have slowed a bit, but it remains stronger than the overall economy. However, to the extent these are subsidized markets, the underlying demand appears unclear."

"We have heard these statements being proudly proclaimed but many wind turbines are still made in Europe or increasingly Asia," Manders says. "Tunnels get dug once, the majority of major rivers have already been dammed and those projects operate 30+ years between refits, etc, etc. These proclamations do very little to sustain industry in the long term."

McGibbon at AMT notes that off-highway, construction, mining and heavy industrial equipment orders *are* up significantly and continue to climb at double-digit rates. "This is by no means the largest market in terms of manufacturing technology, but it's certainly the fastest growing at this point in time. There are some positive signs heading into 2012."

Carpenter is generally optimistic about the future of large-scale manufacturing in North America. "There is no reason a U.S. based manufacturer of highly engineered, mission-critical products can't thrive and win for decades to come. Frankly, many U.S. companies are now "on-shoring" or bringing production back to the United States that they had moved off-shore in the time period since the 1970s. We expect on-shoring to continue as global capacity is constrained and quality expectations continue to rise."

For more information:

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Phone: (708) 298-1100
www.bradfoote.com

Rexnord
4701 W. Greenfield Avenue
Milwaukee, WI 53214
Phone: (866) REXNORD
www.rexnord.com

Vancouver Gear Works
14551 Burrows Road, Richmond B.C.
Canada V6V 1K9
Phone: (604) 278-3111
www.vangear.com

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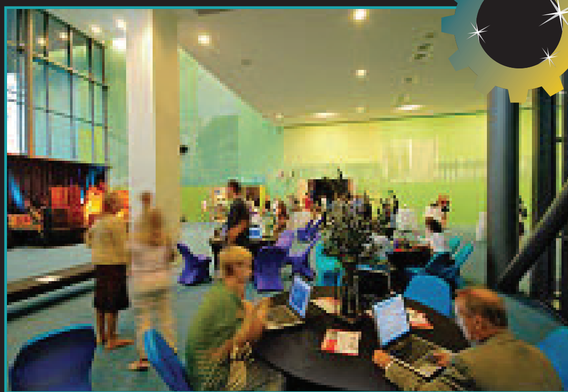

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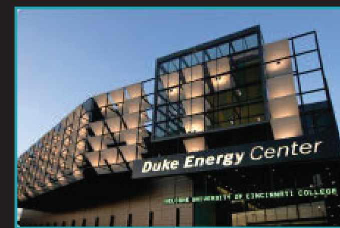

Gears for Industry, Gears for Defense, Gears for Almost Anything at Gear Expo 2011

Jack McGuinn, Senior Editor

What would Gear Expo be without gear manufacturers? While it is useful and indeed necessary to keep abreast of the new machinery out there that will in fact be front-and-center at the show, it is of equal import to check out the finished product—GEARS.

This year's show will boast some 50 gear makers—all of them ready, willing and able to show you what those above-mentioned fancy machines—and generations of experience, design and technical know-how have wrought. We're talking spur gears, helical gears, double-helical gears, bevel gears, hypoid gears, crown gears, worm gears, rack-and-pinion gears, epicyclic gears—you name it—they'll be at Gear Expo 2011.

Now the question is, will you?

In today's cutthroat-competitive environment, it's hard for anyone even tangentially involved in the gear industry to make a case for not being there. This is the venue to learn about gears and confirm what you think you know about gears. Better yet, this is where you get to talk to the people who make them and to learn things you'd never be ever to glean from a website or glossy sales brochure. This is where you get to shake their hand, look them in the eye and get the

continued

Capstan Atlantic will showcase their latest-technology PM gears at the show (courtesy Capstan Atlantic).

straight story.

Following is a summary of interviews we conducted with a number of gear makers exhibiting at Gear Expo 2011.

A question that most every attendee has in mind—and every gear manufacturer had better have an answer for—is "Why should I show up at your booth?"

Forest City Gear Company (FCG) (Booth 632) believes that "Attendees should stop by our booth to learn about our latest equipment acquisitions and therefore our newest gear cutting capabilities," says FCG CEO Fred Young. "They can stop in and get advice on gear quality and processing issues, and, most importantly, for good friends and good conversations!"

Rod Coleman, marketing specialist for EM Gear LLC (Booth 407), says that "Attendees should stop at our both because we will have excellent samples of our workmanship. Seeing is believing in our industry and I believe if individuals stop at our booth they will see how our quality really differentiates our company from our competitors."

"Those attendees who should stop by our booth should be in search of locating a very capable turnkey gear manufacturer with an AS9100- and ISO 9001-registered quality management system and complementary NADCAP (cost effectiveness accreditation program) for heat treating and passivation of stainless steel," says James M. Manning, president of STD Precision Gear & Instrument (Booth 604).

"At Circle Gear (Booth 433), we offer solutions," says Mike McKernin, sales manager. "We are big enough to handle most projects, but we are small enough to recognize the importance of customer service."

Excel Gear (Booth 335) weighs in with "Excel Gear is a proven source for the manufacture of complex, high-precision gears, gear boxes and high-speed spindles, says N.K. Chinnusamy, Excel president. "We are also a provider of design consultation, finite element analysis (FEA) and vibration analysis."

And longtime gear manufacturer Brelie Gear Co. (Booth 309) believes that "Attendees should stop by our booth to learn more about Brelie Gear and the quality gears we offer. We have re-invested very heavily in technology and automation of our gear cutting operations and it shows in the quality of the products we make," says Steve Janke, Brelie president.

From VanGear (Booth 1428) comes something one doesn't necessarily expect at a new-technology show.

"We will be displaying a vintage 1913 Pfauter R0 Hobbing Machine in mint condition," says Jim Mantei, VanGear vice president of business development and operations.

And in keeping with the show's international reach, this from Mushtaq Jamal, executive/engineering, Bevel Gears India Pvt. Ltd. (Booth 1102).

"We are unique bevel gear specialists who can truly problem solve—1:1-ratio hypoids, super-high-ratio hypoids of ratio over 1:100, ground spiral bevel gears, reverse engineering and a range of one-half-inch to 90" bevel gears—all from one source," he says.

Vice president/engineering Richard H. Slattery of powdered metal gear maker Capstan Atlantic (Booth 1003) explains that "Attendees should stop by our booth to get the latest updates on state-of-the-art gear manufacturing technologies associated with powder metallurgy."

And from Riley Gear (Booth 639), "Anyone interested in state-of-the-art custom gears and gear box manufacturing and processes would benefit from a visit to Riley Gear's booth," says Dave Sambuchi, vice president sales.

It's a fact that attendees visit shows looking for the "latest-greatest" and Gear Expo is no exception. It might be a new product or a piece of news yet unknown. Here, from our companies referenced above, is a taste.

What's new at FCG is that "We are becoming more vertically integrated to allow for shorter lead times and to increase our control on quality," says Young. "We now do in-house blanking, MPI and nital etch to help ensure on-time delivery, shortened lead times and to maintain quality requirements."

"We want individuals to know that we are the American representative office of Dae Seong Gear Mfg, Co., says EM Gear's Coleman, adding, "We have recently established an office in the United States called EM Gear."

"Excel Gear will be offering our newly released gear design and analysis software titled *Excel-lent*," says Chinnusamy. "*Excel-lent* will be on display for expo attendees to use and run sample calculations, thereby allowing attendees to experience first-hand the outstanding value of this software for their gear design needs."

And speaking of news, "We have recently earned our ISO 9001-2008 certification," says Brelie's Janke. "Earning this certification is the direct result of feedback we were given by numerous potential customers at the Gear Expo in 2009."

And this just in as well: "We have aligned ourselves with Iwasa Tech from Tokyo to provide spiral bevel gears to the North American market," says VanGear's Mantei. "We will share the same booth space to provide information to all interested parties."

Sambuchi says what's new for Riley Gear is that "(The company) has invested more than $17 million in new plant expansion and equipment since the last gear show in 2009."

Capstan Atlantic, says Slattery, will be showcasing their "PM gears with strength- and fatigue-resistance properties formerly associated only with wrought steel gears, but manufactured at costs associated with the favorable economies of PM. Precision levels have increased and gear crowning is now a production-viable process, with hundreds of thousands of parts in the field."

It is human nature—and good business sense—for exhibitors to maintain a "What have you done for me lately?" mindset when considering show participation. Our contributors here are no exception.

"We expect Gear Expo to really help us expand our brand and name," says Coleman. "Since we are relatively new in the United States, customers will finally get a chance to see some of our product first-hand."

"We expect the show to provide good sales leads, provide a multitude of networking opportunities, allow time to reconnect with industry friends and to see new gear cutting equipment at the machine booths," Young says.

Circle Gear's McKernin says that "The show offers the opportunity to discuss opportunities and available resources

continued

Big-gear applications are fair game for Excel Gear (top) and EM Gear (bottom).

A planetary gear from Forest City Gear.

with similar companies in the gear industry. It is almost impossible to have every piece of machinery for every operation, so it is helpful to have relationships with allies in the industry that can assist in challenging projects."

"At Gear Expo 2011 we expect to introduce Riley Gear to potential new customers as well as give us the opportunity to thank existing customers for their business," says Sambuchi.

"Gear Expo provides a great opportunity to meet current and future customers and to showcase Excel Gear's distinguishing capabilities, Chinnusamy explains.

As with EM Gear, the show also provides companies like Brelie an opportunity for brand awareness and recognition.

"We are looking to use the trade show to help get our name out in the marketplace," Janke says. "Even though Brelie has been making gears since 1930, most people in the industry don't know who we are. Gear Expo is one of the ways we are trying to get our name out there."

VanGear is looking to attract some "good exposure with all the main players on the same stage," Mantei says.

"We expect the show to continue enhancing our visibility to new and existing customers in the U.S. and international markets," says Jamal.

Capstan's Slattery addresses the whole-show experience in pointing out that "We like to see the latest in gear processing and monitoring technologies to ensure that we are utilizing the best tools available."

Before leaving our contributors to their work, we asked them one last question: Of all the shows out there, is Gear Expo your show of shows?

EM Gear: "Gear Expo is our choice of existing trade shows because we have been here before as Dae Seong Gear and now we are displaying our new company EM Gear. Gear Expo has provided us with numerous contacts and several customers during our last appearance and we expect the same results this year."

Circle Gear: "Gear Expo has a very defined audience," McKernin explains. "The benefits from this show are based on both your approach and expectations from that audience."

Excel Gear: "Absolutely. Gear Expo is the premier event for gear and gear machine manufacturers and users."

Brelie Gear: "Gear Expo draws attendees from numerous market segments, which helps us with our goal of getting our name out there across a broad range of segments."

VanGear: "As a general venue, absolutely!"

Riley Gear: "Gear Expo is the only trade show Riley Gear attends," says Sambuchi. "It's the only one we need."

Bevel Gear India: "Gear Expo certainly is one of our preferred choices for trade shows, especially in the North American region. As a result of our participation in the 2007 show, we purchased the bevel line of an OEM stock gear manufacturer, won a long-term supply contract and are now their sole suppliers for over 250 bevel parts."

Capstan Atlantic: "Gear Expo is ALWAYS time well spent."

(For more information about any of the gear suppliers exhibiting at Gear Expo 2011, please consult the table to the right):

Gear Suppliers at Gear Expo 2011

Company	Website	Booth #
AA Gear LLC	www.aa-gear.com	328
ABA-PGT Inc.	www.abapgt.com	940
Acuger Precision Corp.	www.acuger.com	1134
Ancon Gear & Instrument Corp.	www.ancongear.com	322
Arrow Gear Co.	www.arrowgear.com	1303
Artec Machine Systems	www.artec-machine.com	320
Bevel Gears India Pvt. Ltd.	www.bevelgearsindia.com	1102
Bowmar LLC	www.bowmarllc.com	231
Brad Foote Gear Works (see ad on p. 14)	www.bradfoote.com	217
Brelie Gear Co.	www.breliegear.com	309
Broadway Gear	www.broadwaygear.com	1209
Capstan Atlantic	www.capstanatlantic.com	1003
China National Aero-Technology Import & Export Co.	www.catichz.com	506
Cincinnati Gearing Systems (see ad on p. 4)	www.cincinnatigearingsystems.com	1232
Circle Gear & Machine Co. (see ad on p. 11)	www.circlegear.com	433
CORDM	www.cordm.com	638
Custom Gear & Machine Inc.	www.cgearinc.com	703
Davall Gears Ltd.	www.davall.co.uk	802
Delta Gear (see ad on p. 28-29)	www.delta-gear.com	1311
EES Gear GmbH	www.ees-gear.ch	131
EM Gear LLC	www.em-gear.com	407
Excel Gear Inc. (see ad on p. 54)	www.excelgear.com	335
Fairfield Manufacturing Co. Inc.	www.fairfieldmfg.com	1227
First Gear	www.first-gear.com	603
Forest City Gear Co. (see ad on p. 3)	www.forestcitygear.com	632
Gear Technology	www.gear-tech.com	811
GearKing Inc.	www.gearking.com	1415
GearWorld North America	www.gear-world.com	1139
Great Taiwan Gear Ltd.	www.taiwangear.com	1226
Hangzhou Advance Gearbox Group Co. Ltd.	www.chinaadvance.com	127
Innovative Rack & Gear Co.	www.gearacks.com	504
JiangSu Hefute Gear Manufacturing Co. Ltd.	www.hefute.com	507
Li Gear Inc.	www.ligear.com	1103
Minchen Gear Co. Ltd.	www.minchen.com.tw	1033
Northern Tool & Gear Co. Ltd.	www.ntgear.co.uk	1427
Perry Technology Corp.	www.perrygear.com	438
Presrite Corp.	www.presrite.com	933
Raycar Gear & Machine Co.	www.raycargear.com	1431
Reliance Gear Corp.	www.reliancegear.com	1420
Riley Gear Corp.	www.rileygear.com	639
Seitz Corp.	www.seitzcorp.com	1203
Spencer Pettus Machine Co.	www.spgear.com	1306
STD Precision Gear	www.stdgear.com	604
Supreme Industrial Works	www.gearsupreme.com	211
SuZhou Asia Pacific Metal Co. Ltd.	www.gear-manufacturer.com.cn	230
Thermotech Inc.	www.thermotech.com	210
United Gear & Assembly Inc.	www.ugaco.com	1416
VanGear	www.vangear.com	1428
Zhejiang Hengfengtai Reducer Mfg. Co. Ltd.	www.cnhtr.com	711

Best Practices

FOR SELECTING AND SIZING GUIDE WHEELS

Leslie Lui, mechanical design engineer
Bishop-Wisecarver Corporation

Introduction

For over 40 years, Bishop-Wisecarver has been developing best practices for matching guide wheel systems to customer requirements based on engineering and empirical experience. By sharing this knowledge and experience, selecting a guide wheel with the properties best-suited for a given application becomes easy and results in a system that reduces design costs and engineering changes, as well as lower warranty, assembly, installation and mounting costs.

Linear guide systems are chosen for an application based not only on their precision and speed characteristics, but also on a host of other operating conditions such as environment, length, speed, duty cycle and temperature, to name a few. Guide wheel systems should not be overlooked; in many applications and environments they have notable advantages.

Well-known for their ability to outperform re-circulating ball technology in harsh environments due to their completely enclosed ball bearings and raceways, guide wheel sys-

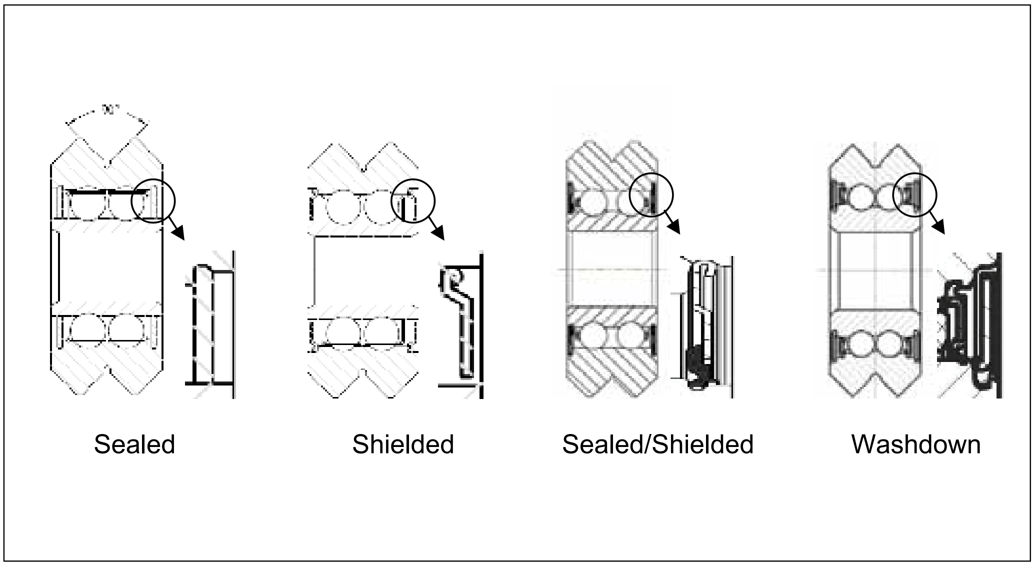

Figure 1—Application environment determines the type of required guide wheel bearing protection.

tems also have other lesser-known yet distinct advantages. They routinely operate in environments with low noise level requirements, high (up to 500° F) or low (as low as –94° F) operating temperatures, wash-down practices, high humidity and/or very long travel lengths. They can meet flatness, parallelism and straightness tolerances as tight as ± 0.001" (± 0.03 mm), and, compared to other linear guide systems, guide wheels have less friction, are much faster to assemble and are very cost-efficient.

By matching the component properties of a guide wheel system to a given application, engineers can ensure trouble-free operation over the system's predicted lifespan—as well as reduced costs, lead time and field failures. The types of wheel and track selected must be matched to all application requirements, including environment, loads, accuracy, life cycle and cost. Bishop-Wisecarver has developed the following process for ensuring the best match of guide wheel system to application, beginning with the operating environment to calculate the required size of the wheel.

Bearing Type Selection

The environment determines the type of guide wheel bearing protection required.

Sealed. Environments with heavy concentrations of liquid or fine/powdery particulates can displace and/or change the properties of the bearing lubricant, causing premature wear and failure of the bearing balls and raceways. Specifying a sealed bearing for this operating environment can prevent damage to the bearing elements, ensuring the predicted lifespan of the system.

Shielded. Generally, shielded bearings are used in environments with heavy concentrations of large particulates—such as metal flakes—that can work their way between the balls and bearing raceways. The larger debris can cause premature wear and damage—i.e., brinelling or spalling.

Sealed and shielded. Bearings that feature shields *and* seals offer the advantages of both sealed and shielded wheels. The shield protects the seal from damage by large particulates while the seal protects the bearing elements from the fine particulate and liquid that the shield is less effective against.

Special configurations. The wash-down bearing includes a patented inner seal and outer shield design. The design of the outer shield allows it to act as a momentary seal while pressure from high-velocity fluid causes the shield to deflect and conform to the wheel's metallic surface. When the pressure is removed, the shield returns to its normal position, allowing any liquid and debris that entered between the shield and seal to drain out or be spun out by centrifugal force.

(Author's Note: In contaminated environments, a de-rating factor based on the severity of the contamination must be used for sizing. This is discussed later in Load/Life Equation—Sizing and Selection.)

Selection of Wheel, Track and Bearing Material

Wheels. Wheels are available in a variety of materials to suit a wide range of applications. The most commonly used materials are 440C stainless steel, 52100 carbon steel and polymer. Stainless steel materials should be used in humid, liquid and corrosive environments. Although highly corrosion-resistant, some corrosion can in fact occur with stainless steel, depending on the severity of the environment. Polymer wheels offer certain benefits, including chemical resistance, low friction and low noise. Polymer wheels have reduced load performance versus steel wheels, but polymer wheels are an economical choice for light-load applications and harsh chemical environments.

Track: Standard track materials include AISI 1045 carbon steel and AISI 420 stainless steel; other track materials include aluminum, which can be used with polymer guide wheels. The 1045 is a medium-carbon steel with good strength and hardness properties (53 HRC hardened; 22–25 HRC unhardened) that minimizes wear. The 420 stainless steel contains just enough chromium to limit corrosion, yet can be hardened up to 45 HRC (20–22 HRC unhardened).

Stainless or carbon steel track are equally effective in environments with heavy concentrations of large particulates and flakes, because contaminants are swept away when the wheel passes over the track. Since the wheel has a smaller diameter at its inner-V compared to its outer-V, the wheel's inner-V travels at a slower rate than the outer-V on the track. This creates a velocity gradient that pushes the debris outward, resulting in an especially clean track.

When selecting the track material, it is generally advised not to specify a material softer than the wheel material, as this can result in the track material galling onto the wheel, damaging the track, wheel and payload, and

continued

requiring time-consuming and expensive repair of the system. However, a notable exception to this rule is that it *is* acceptable to use hardened steel-track material with steel wheels—despite the track having marginally less hardness than the wheels.

Operating Temperature and Lubrication

As stated, guide wheels can accommodate up to 500° F for operation in environments with high temperatures, and as low as –94° F for operation in low-temperature applications.

If accuracy is crucial, stainless steel wheels can be heat treated to the point where they become very thermally stable, thus minimizing growth. For example, carbon steel, stainless steel and polymer wheels all can withstand the temperature and duty cycle of autoclaving. To sterilize instruments and equipment, an autoclave must reach a minimum of 121° C (250° F) for 30 minutes.

Lubrication is key in maintaining a long service life and minimizing field failure. Internally, guide wheels are lubricated for life with an extreme pressure- and corrosion-resistant grease, but the lubrication of the wheel/track interface is the responsibility of the user. Lubricator assemblies prevent damage to bearings and help prevent corrosion—even in stainless steel systems. In our experience, most bearing failures are caused by either an inadequate, incorrect—or complete lack of—lubricant.

In high-temperature operating environments, lubrication is especially important. Friction caused by the wheels rolling across the

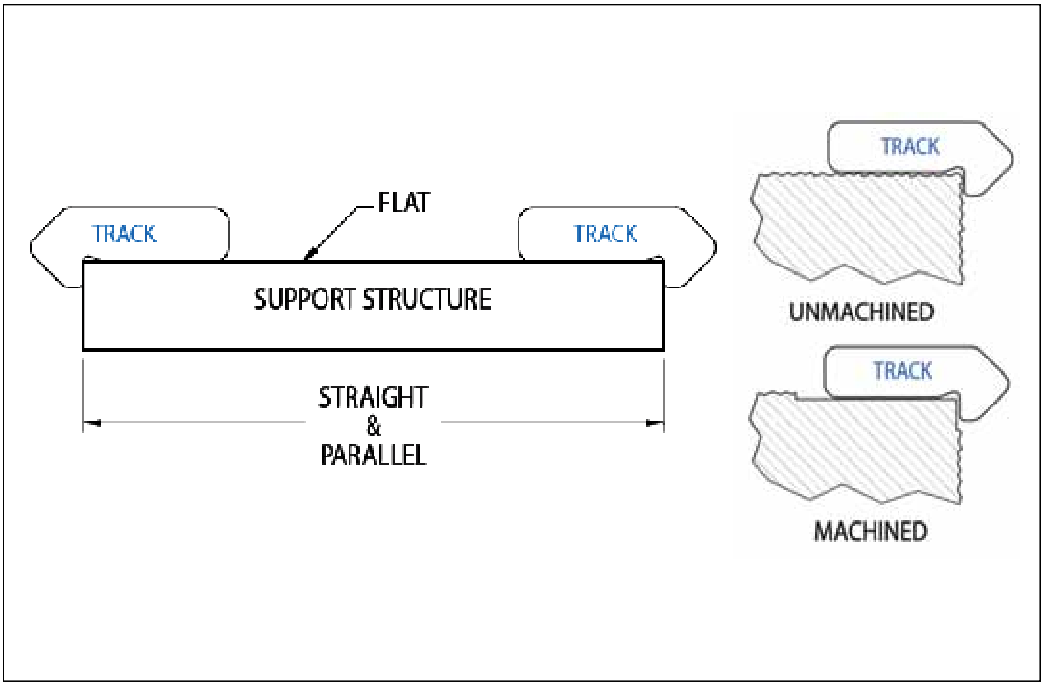

Figure 2—Cold-finished or extruded bar plate is accurate enough to serve as the support structure for most applications, although greater accuracy can be obtained by machining the surfaces on the support structure used for mounting the track.

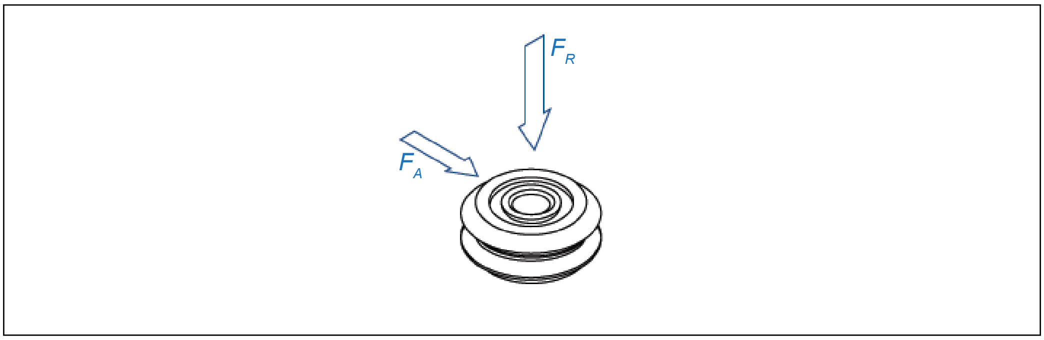

Figure 3—Service life of a properly designed guide wheel system is limited to that of the most heavily loaded wheel bearing. In typical scenarios, start with determining whether the loads are radial and/or axial.

track generates additional heat at their interface that can lead to excessive heat buildup in the wheel and cause the contact surfaces to gall. This potentially leads to excessive brinelling or spalling on the rolling contact surfaces—and eventual premature failure of the system. The use of guide wheels with high-temperature grease and proper track lubrication will help decrease friction-generated heat buildup and protect against premature system failure.

Noise

Industrial environments generally tend to be forgiving of loud noise. However, noise is an issue in applications that are in proximity of the general public. For example, patients can be unnerved when in contact with noisy medical devices; noisy guide-way systems for CAT scans and MRI equipment can make patients needlessly uncomfortable. Guide wheel technology can effect a 20% noise reduction, as compared to square-rail or round-rail systems.

The ball bearings in a guide wheel follow a constant radius raceway path, while the ball bearings in square rails follow an oval raceway path with widely varying radii. A square rail has straight sections with radii at the ends, and thus a 180° arc. The ball bearings move along alternating straight and semi-circular paths, forming a complete circuit. The sudden change in the ball's trajectory when transitioning from the straight to the semi-circular section precipitates heightened noise and vibration. Occasionally, polymer cages are used to reduce the noise of the ball bearings, but they are not completely effective.

Tolerances and Track Mounting

The track does not require additional, costly grinding and finishing operations to achieve tight tolerances. The flatness, straightness and parallelism of the support structure surface on which the track is mounted or bolted determine the accuracy of the linear guide system. As such, designs requiring less accuracy will also require less surface preparation and, therefore, will result in significant time and cost savings.

For example, if only ±0.004-in. tolerances are required, a guide wheel system can be bolted to a less-than-even surface; surface preparation is minimal and installation time and costs are low. However, for systems requiring ± 0.001 in., better mounting-surface preparation is required.

Loads

The service life of a properly designed guide wheel system is linked with that of the most heavily loaded wheel bearing. Therefore, loads must be evaluated to predict lifespan and minimize warranty and in-field repair costs. However, load evaluation can be fairly tricky; it therefore is extremely important to understand *exactly* the conditions under which the guide wheel will be used.

Generally, we start with determining whether the loads are radial and/or axial:

F_R: Radial load refers to the load applied in a direction perpendicular to the axis of

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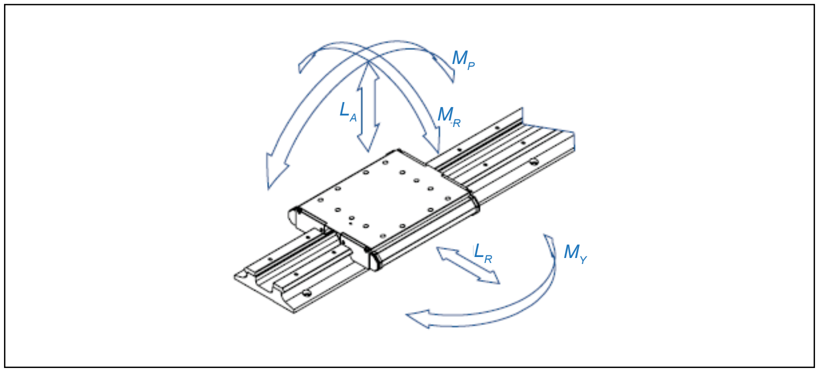


Figure 4—Systems with guide wheel-equipped wheel plates can be used in both linear and moment loading conditions.

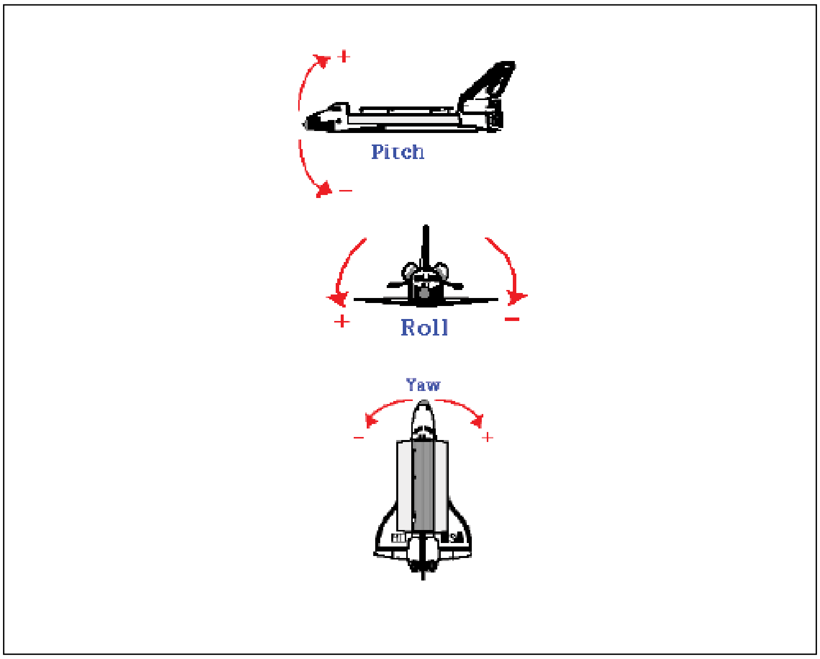


Figure 5—M_P is a "moment load" in the pitch direction. Pitch loading can be likened to an airplane climbing or descending. "Pitch moments" occur when a force wants to tilt the wheel plate up or down; M_R is known as "a roll moment." When an airplane banks left or right, this is considered movement in the roll direction. A roll moment occurs when the wheel plate is subjected to a load that makes the wheel plate want to tilt like an airplane banking; M_Y is a "yaw moment." Yaw occurs when an airplane turns left or right. The wheel plate is subjected to loading that impels the wheel plate to rotate left or right.

rotation.

F_A: Axial load refers to the load applied in a direction parallel to the axis of rotation.

We use a formula based on empirical data that is very easy to apply and reasonably accurate with regard to lifespan based on field experience. (*See* Load/Life Equation: Sizing and Selection.)

Standard bearing equations do not apply to wheels that are axially loaded, because the axial load is not uniform on the wheel. Axial loading will, in fact, result in a moment load on the wheel, causing uneven loading on the ball bearings—unlike a thrust bearing where the load is distributed equally on all the balls. The wheel can accept higher moment loads by increasing the radial preload, but this leads to a much higher wear rate.

Systems with guide-wheel-equipped wheel plates can be subjected to both linear and moment loading conditions. Moment loads on a wheel plate are forces that cause torque loading around the wheel plate's coordinate axes.

Load/Life Relationship

Several factors influence the service life of a guide wheel system. We have devised a simple method to estimate the load/life relationship for a specific guide wheel system under defined loading conditions. This methodology accounts for the size of the bearing elements as well as

Table 1—Typical Guide Wheel Load Capacities: Steel & Stainless Steel

Size		0	1	2	3	4	4XL
Axial F_A	N	123	252	625	1,701	4,001	6,552
	lbf	28	57	141	382	900	1,473
Radial F_R	N	650	1,220	2,650	5,900	9,700	14,300
	lbf	146	274	596	1,326	2,181	3,215

Table 2—Life Equation Adjustments

Adjustment Factor (A_F)	Application Conditions
1.0 - 0.7	Clean, low speed, low shock, low duty
0.7 - 0.4	Moderate contaminants, medium duty, medium shock, low to medium vibration, moderate speed
0.4 - 0.1	Heavy contamination, high acceleration, high speed, medium to high shock, high vibration, high duty cycle

Table 3—Wheel Size/Life Constant L_C

Wheel Size	Inches of Travel life	Kilometers of Travel Life
0	1.65×10^6	41
1	2.19×10^6	55
2	3.47×10^6	87
3	5.19×10^6	130
4	6.84×10^6	171
4XL	8.58×10^6	215

the relative spacing and load orientation, location and magnitude. The equation is based on clean, well-lubricated track conditions, so applications where lubrication is prohibitive require application of a de-rating factor.

It is important to note that secondary considerations such as maximum velocity; acceleration rates; duty cycle; stroke length; environmental conditions; shock and vibration; and extreme temperature ranges can all impact service life to varying degrees. As such, this sizing method is considered only as a guideline for guide wheel components and assemblies.

Load/Life Equation: Sizing and Selection

Load/life estimation requires a basic understanding of the principles of statics, the ability to work with free-body diagrams and the capacity to resolve externally applied forces on a wheel plate into the radial and axial reaction forces at each guide wheel in the design. The life of a guide wheel system is limited to the life of the most heavily loaded bearing in the design.

Step 1: ***Calculate the resultant radial (F_R) and axial (F_A) loads reflected to each bearing element in the linear guide design.***

All standard considerations involved in statics calculations must be accounted for, including inertial, gravitational and external forces such as tool pressure, bearing element spacing and magnitude/direction of the payload. Any external forces that generate a reaction through the wheel/track interface must be considered.

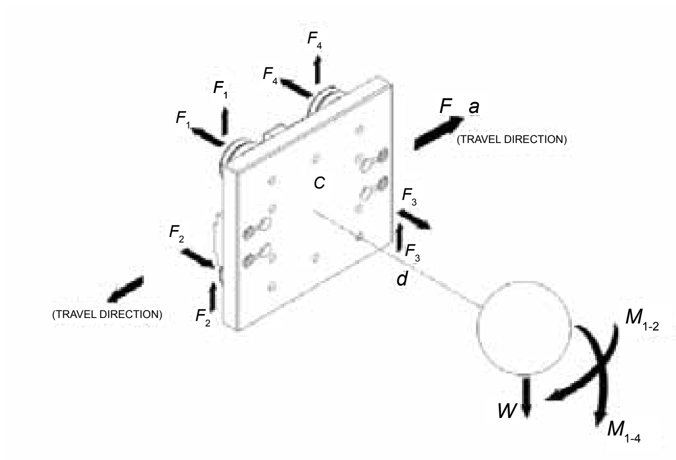
Step 2: ***Calculate the load factor for the most heavily loaded bearing.***

$$L_F = \frac{F_A}{F_{A(max)}} + \frac{F_R}{F_{R(max)}} \qquad (1)$$

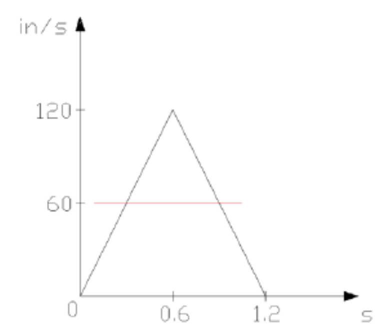
Where:

- L_F = Load factor
- F_A = Resultant axial load on guide wheel
- F_{Amax} = Maximum axial working load capacity of guide wheel
- F_R = Resultant radial load on guide wheel
- F_{Rmax} = Maximum radial working load capacity of guide wheel

- Bearings should be sized such that $L_F \leq 1$
- The most heavily loaded bearing will have the highest load factor (See Table 1)



- Move 250 lb mass (24" x 12" x 12")
- Center of Gravity (CG) centered, d = 12.0
- 72" of travel in 1.2 seconds with a triangular velocity profile
- Orientation as shown with movement along the Y-axis
- Wheel spacing cannot be any larger than 10" apart in Y and Z-axis



V_{AVG} = 60 in/s

V_{MAX} = 120 in/s

Acceleration = (120 in/s) /(0.6 s) = 200 in/s^2 (0.52 G's)

Figure 6—Sizing DualVee guide wheels.

Step 3: ***Calculate life by applying the load factor to the load/life equation below.***

Due to varying application load and speed parameters and environmental conditions, an appropriate adjustment factor must be applied to the life equation (See Table 2).

continued

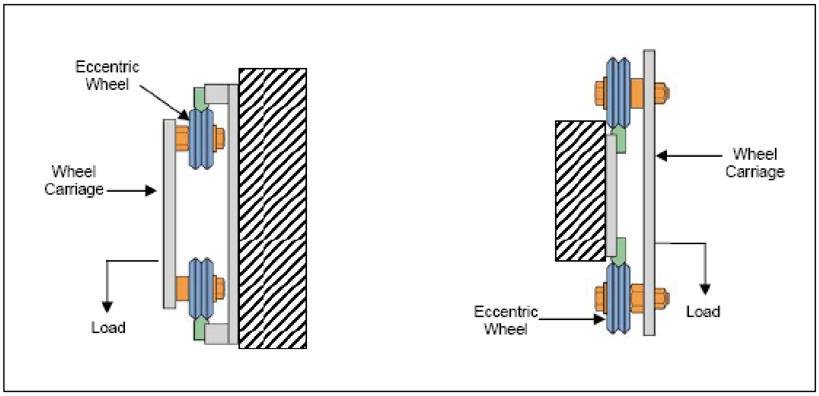


Figure 7—It is important to note that the optimal locations of the eccentric and concentric wheels relative to an applied radial load are dependent on whether the tracks are between or outside of the wheel plate's two rows of wheels.

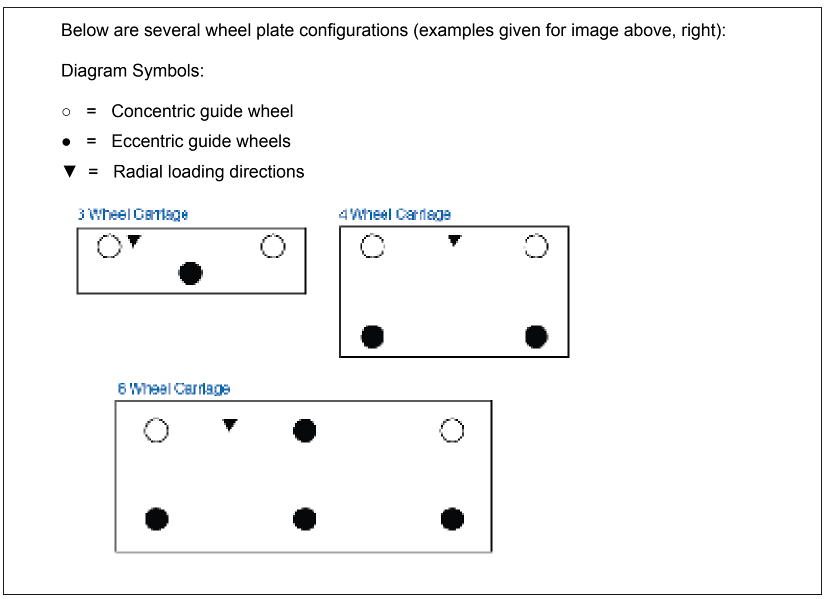


Figure 8—Wheel plate configurations for example shown in Figure 7/right.

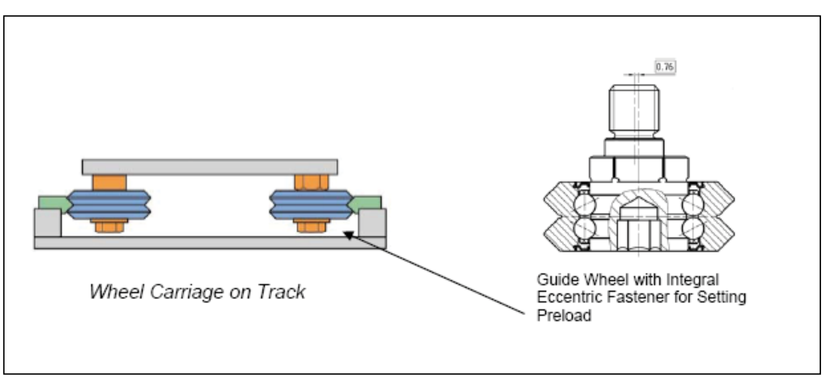


Figure 9—In assembling the system, the wheel plate should be placed on the tracks with no load attached and with the concentric wheels fully tightened and the eccentric wheels tightened just sufficiently to permit adjustment.

$$\text{Life} = \left(\frac{L_C}{(L_F)^3}\right) A_F \qquad (2)$$

Where:

L_F = Load factor
L_C = Life constant
A_F = Adjustment Factor

Calculation example **(Table 3):**

F_A = 50 lbf
F_R = 200 lbf
Wheel size = 2
Environment = moderate shock loading and contamination with intermittent motion

Following the outlined procedure, we know the information from Step 1—radial (F_R) and axial (F_A) loads on each wheel—and are therefore ready to calculate that:

F_A = 50 lbf
F_{Amax} = 141 lbf
F_R = 200 lbf
F_{Rmax} = 596 lbf
L_F = 50/141 + 200/596 = .69
Life = $3.47 \times 10^6 / (.69)^3 \times 0.6$ = 6.33×10^6 inches of travel

Note that an adjustment factor of 0.6 was used due to the environmental influences.

How to Size DualVee Guide wheels

The versatility of DualVee allows for an infinite number of wheel plate sizes; for this example we will restrict the size to a particular dimension (spacing between wheels). Many applications entail size limitations due to space constraints (Figures 6–7).

***Force due to load*:**

$\Sigma M_{1,4}$ = 10"($F_{2,3}$) + 12"(250 lbf) = 0
$F_{2,3}$ = 300 lbf →
F_2 = F_3 = 150 lbf (axial)
ΣF_X = $F_{2,3} + F_{1,4} = 0$
$F_{1,4}$ = 300 lbf ←
F_1 = F_4 = 150 lbf (axial)
ΣF_Z = 250 lbf + $F_{1,4}$ = 0
$F_{1,4}$ = 250 lbf
F_1 = F_4 = 125 lbf (radial)

Force due to acceleration:

$\Sigma M_{1,2}$ = 12" (250lbs) (0.52 G) + 10" ($F_{3,4}$) = 0
$F_{3,4}$ = 156 lbf ←
F_3 = F_4 = 78 lbf (axial)
Σ_{FX} = $F_{3,4} + F_{1,2} = 0$
$F_{1,2}$ = 156 lbf →
F_1 = F_2 = 78 lbf (axial)

Total force on highest-loaded wheel:

F_4 = 125 lbf (radial)

F_4 = 150 lbf (static loading) + 78 lbf (force due to acceleration) = 228 lbf (axial)

Estimated wheel life under ideal environmental conditions:

$L_F = L_A / L_{Amax} + L_R / L_{Rmax}$

$Life = L_C / (L_F)$

For a size-3 wheel (given working load capacity of L_A = 382, L_R = 1,326):

L_F = 228 / 382 + 125 / 1,326 = 0.691

$Life$ = 5.19×10^6 in / $(0.691)^3$ = 1.57×10^7 in

Wheel plate configurations. In designing a wheel plate, it is important to use the right combination of eccentric and concentric guide wheels, as dictated by the configuration. The linear systems should always have two *concentric* wheels while the remaining guide wheels should be *eccentric*. The eccentric wheels are used to eliminate play (clearance) between the wheels and tracks and allow preloading of all the wheels so that they roll smoothly rather than sliding or skipping on the track. If the wheel plate is loaded in the radial direction, the concentric wheel should support as much of the radial load as possible.

It is also essential to recognize that the optimal locations of the eccentric and concentric wheels—relative to an applied radial load—are dependent on whether the tracks are between or outside of the wheel plate's two rows of wheels.

Figure 8 displays wheel plate configurations relative to the sample shown in Figure 9/right.

Preload

Wheel plate preloading creates radial loading between the wheels and tracks that exists when the system is not loaded by another outside force, and serves to eliminate play between the wheel and track. Preload is determined by:

$$\text{Preload} = \frac{\text{measured wheel plate breakaway force}}{\text{number of wheels x coefficient of friction}}$$

Preload adjustment is accomplished by gradually rotating the eccentric wheel bushing(s) until the tracks are held captive by the two sets of wheels on each side of the wheel plate—with no apparent clearance between the tracks and wheels and very light preload. Once this is accomplished:

- Fasten the eccentric wheel(s) so that they hold their positions.
- Next, check each wheel for correct preload by rotating the wheel with your fingers, while holding the track stationary. The wheel should skid against the track with a small amount of resistance, but should still turn without much difficulty. If rotation is not possible, the preload should be reduced accordingly by readjusting the eccentric wheel(s).

Caution must be used when applying preload because too much preload on the wheels can cause premature failure. The rated radial load should never be exceeded by the preload and subsequent radial loads that are applied to the wheel when in service. Note that preloading cannot compensate for large variations in track parallelism tolerances, which can occur in long travel length systems.

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Step Motor Lower-Loss Technology—An Update

Yatsuo Sato, Oriental Motor

Management Summary

The demand for stepping motors with high efficiency and low losses has been increasing right along with the existing focus on high torque. The selection of the most suitable grade and improvement in the fastening of the laminated cores has reduced losses significantly at their peak when compared to conventional stepping motors. Lowering the losses of the motor has enabled continuous operation previously considered impossible. An expansion of the stepping motor's usage into applications where another type motor has been used for continuous operation and other uses due to heat generation issues is now within reach. In addition, these motors are very effective for energy savings; this paper explains the technology used for lowering the iron loss in stepping motors.

Introduction

The stepping motor can control the speed and position accurately in an open loop control mode, but its disadvantage has been excessive heat generation when rotating at high speed. On the other hand, its ease of use has been a clear benefit. The stepping motor has been used mainly to utilize standstill holding brake force and torque at low speed. Another recent customer demand—the ability to operate continuously at high speed, thus shortening cycle equipment time—is yet another challenge. That challenge has been met by the use of both an enhanced lamination sheet and fastening method for the laminated iron core—greatly reducing motor loss when compared with the conventional stepping motor. The example motor shown in Table1 is selected as the conventional stepping motor described in this paper.

Losses of Stepping Motor

Classification of losses. Figure 1 shows the losses that are classified when a motor is rotating. The total losses are divided into the driver losses generated in the driver and the motor losses generated in the motor. The majority of the motor losses are copper and iron losses. The copper loss is a loss generated by the current flowing to a stator (stator winding); the iron loss is generated by the flux change in the core. The flux in the core changes by rotation of the rotor (field) or a current change of the stator (stator winding); the iron losses can therefore be classified as an iron loss by the field and the other by the stator winding. Hereafter, the former is called *field iron loss*; the latter, *stator winding iron loss*.

The iron losses can be classified into eddy current loss and hysteresis loss based on the magnetic generation principle. Other losses include mechanical loss and stray load loss. However, this discussion will disregard them—as well as those in the iron losses—because they are small enough to do so when compared with the iron and copper losses.

Field iron losses. Figure 2 shows a structure of the stepping motor. A hybrid-type stepping motor uses a permanent magnet for the rotor and equips the inductors—or teeth—on the outer diameter of the rotor core and inner diameter of the stator core. Iron loss is generated as the rotor rotates because the teeth periodically face and the flux in the stator core changes periodically. This is called field iron loss, as stated above.

Figure 3 shows a measurement system for the field iron losses. A torque meter is set between an external driving motor and a motor to be measured; the rotor is rotated from outside. The rotational speed and the torque are measured and the iron loss is calculated by Equation 1 as:

$$W_0 = (2\pi / 60) \cdot N \cdot T \qquad (1)$$

W_0	=	Field iron loss (*W*)
N	=	Rotating speed (*r/min*)
T	=	Torque (*N·m*)

As mentioned, the iron losses consist of the eddy current loss and the hysteresis loss; each loss-per-unit-mass is expressed as:

$$W_e = c_e \cdot B_m^{\,2} \cdot t^2 \cdot k^2 \cdot N^2 \qquad (2)$$

$$W_h = c_h \cdot B_m^{\,1.6} \cdot k \cdot N \qquad (3)$$

W_e	=	Eddy current loss (W/kg)
W_h	=	Hysteresis loss (W/kg)
c_e, c_h	=	Iron loss constant determined by material
t	=	Thickness of lamination sheet (mm)

continued

Table 1—Specification of conventional stepping motor	
Frame size	60 mm
Length	60 mm
Phase	2 phase
Pole pair	50
Resistance	1.6 ohm
Rated current	1.7 A
Maximum holding torque	1.2 Nm

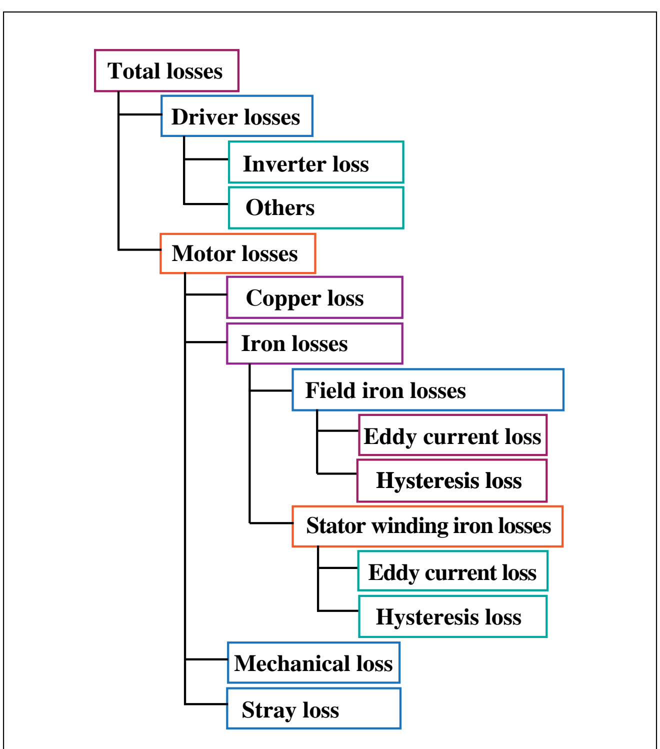

Figure 1—Classification of losses.

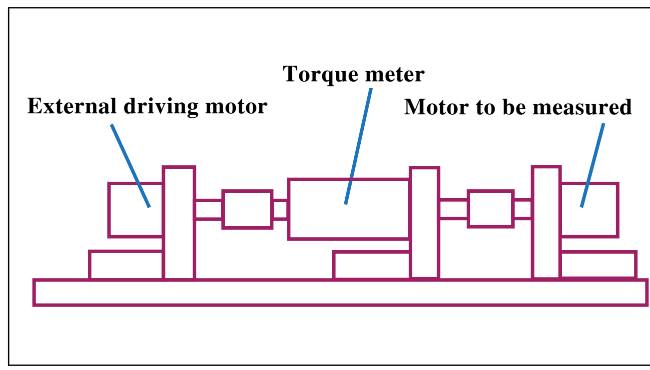

Figure 2—Measurement system of field iron losses.

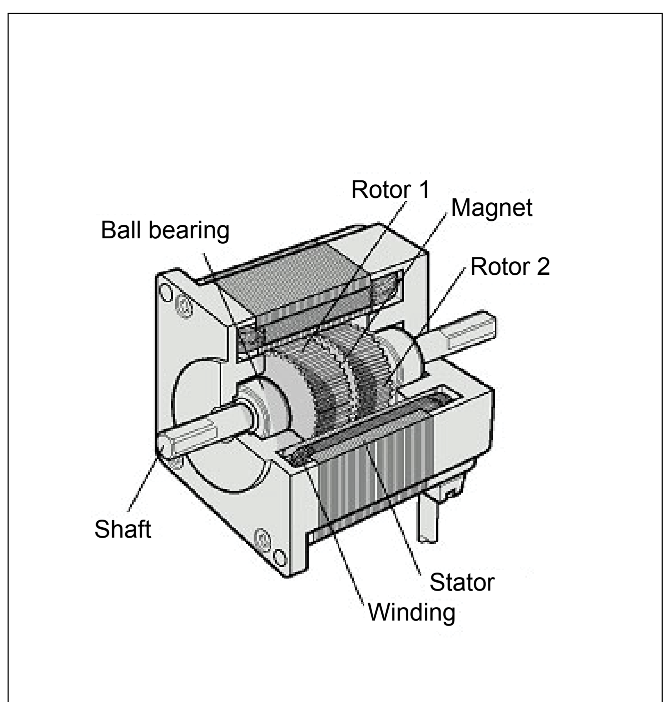

Figure 3— Structure of stepping motor.

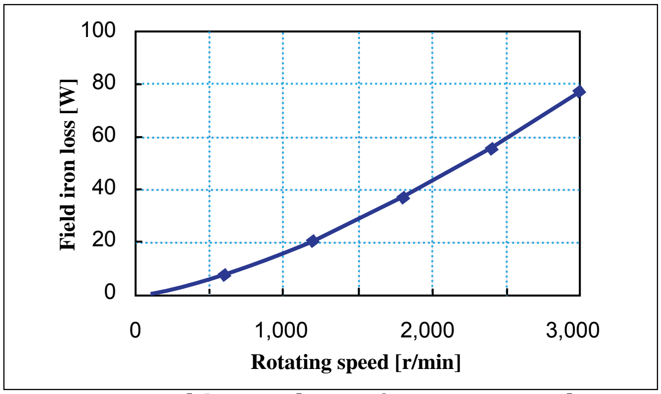

Figure 4—Field iron loss of conventional stepping motor.

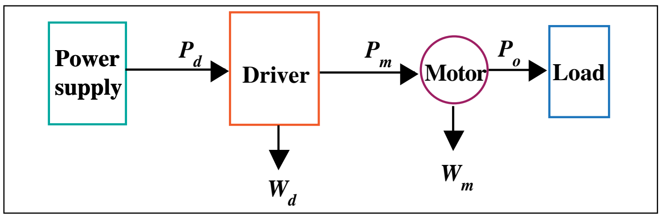

Figure 5—Configuration diagram of loss measurement.

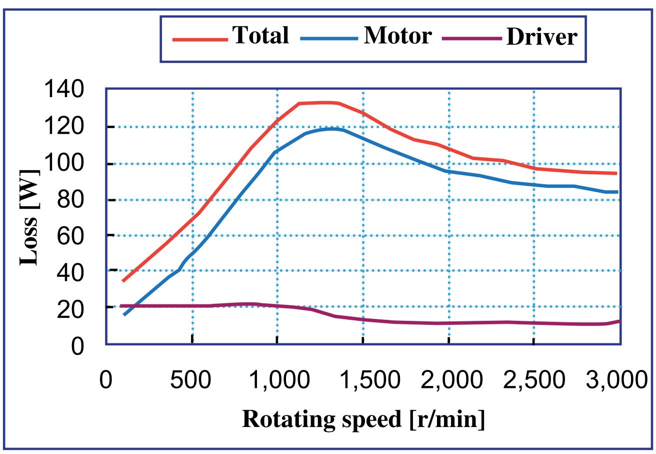

Figure 6—No-load loss of conventional stepping motor.

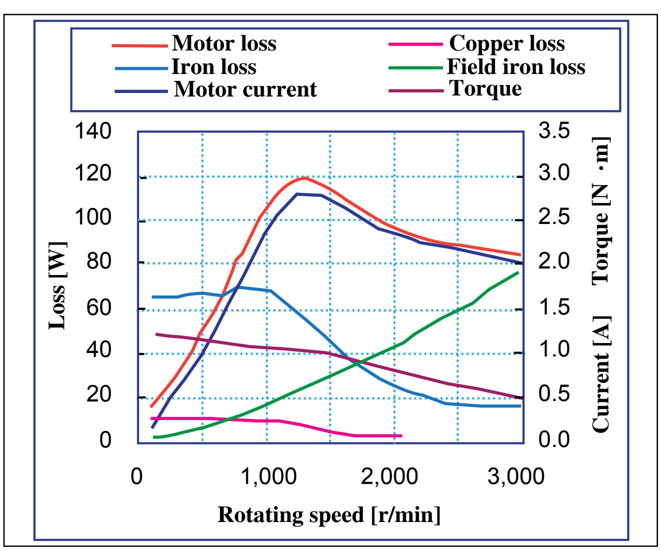

Figure 7—Motor loss of conventional stepping motor.

k	=	Constant by number of pole pair
B_m	=	Flux density (T)
N	=	Rotating speed (r/min)

These equations demonstrate why the eddy current loss is proportional to the square of the rotational speed, and the hysteresis loss is proportional to the rotating speed. The iron loss is a sum of the eddy current loss and the hysteresis loss; it is proportional to the 1st ~ 2nd power of the rotational speed. Figure 4 shows field iron loss in the conventional motor (Eq. 4; approximately), and is proportional to the 1.44th power of the rotational speed.

$$W_0 = 7.84 \cdot 10^{-4} \cdot N^{1.44} \quad (4)$$

Separation of motor losses. The configuration diagram of the loss measurement is shown in Figure 5. A power meter is set between the power supply and the driver, and the driver and the motor, respectively, for measuring power and current.

The driver input, motor input and the output are assumed to be P_d, P_m, and P_o, respectively. The difference between the driver input and the output makes a total loss W_u and the difference between the motor input and the output makes a motor loss W_m. Each value is expressed by the following:

$$W_u = P_d - P_o \quad (5)$$

$$W_m = P_m - P_o \quad (6)$$

The difference between driver input and motor input is driver loss W_d and is expressed by:

$$W_d = P_d - P_o \quad (7)$$

The stepping motor is controlled with a driver so that a constant current may flow, regardless of load; a smaller load therefore results in greater loss.

Consequently, the loss evaluation of the no-load stepping motor is the severest. When assuming $P_o = 0$ (Eqs. 5–6), the whole driver input results in a total loss; the whole motor input results in a *motor loss*. Figure 6 shows the no-load loss of the conventional stepping motor. It is understood that the motor loss is relatively significant when compared with the driver loss.

This brings us to the separation of the motor losses.

Motor copper loss is calculated by:

$$W_c = n \cdot I^2 \cdot R \quad (8)$$

Iron loss follows with:

$$W_{fe} = W_m - W_c \quad (9)$$

W_c	=	Copper loss (W)
W_{fe}	=	Iron loss (W)
n	=	Number of phases
I	=	Current in RMS value (A)
R	=	Winding resistance (ohm)

Figure 7 shows the result of separating the conventional stepping motor's loss from both copper and iron loss. The motor current, torque and field iron loss are described for reference.

Although the current of the stepping motor is controlled to be at a constant value in the fixed-current area of 1,000 r/min or less, the current decreases at higher speed. This is because the voltage to operate the constant-current control becomes insufficient due to an increase in impedance at high speed. The area where the current decreases is known as a "constant-voltage area."

Figure 7 also shows maximum motor iron loss at about 1,200 r/min. In practice, iron loss during rotation is greater than the field iron loss because the stator winding iron loss is added to the field iron loss. The difference therefore between the iron loss and the field iron loss is a stator winding iron loss. The stator winding iron loss decreases in the constant-voltage area because the current is also decreased. The conventional motor has a characteristic in which field iron loss becomes equal to iron loss at about 3,000 r/min.

Though the motor loss is the sum of both iron and copper loss, the copper loss is relatively small and the motor loss is almost equal to the iron loss at high speed. The maximum loss of the conventional motor is 119 W—of which iron loss is 112 W—or 94% of the motor loss. Reduction of iron loss is thought to be an effective development for mitigating the loss of a stepping motor.

Lower-Loss Technology for a Stepping Motor

Lower iron loss using suitable lamination sheet. Two methods are derived from Equations 2–3 for lowering iron loss:

1. Material with a small iron loss constant (c_e, c_h) is used.
2. A thin lamination sheet is used.

The above become possible by changing the grade and thickness of the lamination sheet.

Iron-loss-per-unit mass:
Lamination Sheet 1 > Lamination Sheet 2 >
Lamination Sheet 3 > Lamination Sheet 4

Stator cores were made for trial purposes with the above lamination sheets; a comparison of their maximum loss is shown in Figure 8. The vertical axis shows the ratio based on the motor loss of Lamination Sheet 1; the comparison of loss by material was conducted under the same conditions of holding torque.

In general, reduced iron loss is achieved with use of a higher-grade lamination sheet. However, the saturation flux density will then also tend to decrease when the specified value in iron loss becomes small. When used for the motor, the torque becomes smaller; the current was adjusted to create a uniform torque. Therefore the smaller the specified value in iron loss from the lamination sheet, the greater the copper loss.

And yet—saying the smaller the specified value in iron loss of the lamination sheet, the smaller the field iron loss—doesn't necessarily mean that the specified value in iron loss of the lamination sheet in the condition of a constant torque applies. That's because the stator winding iron loss depends on the current; it reverses the iron loss value in Lamination Sheets 3 and 4. The best lamination sheet was selected, considering not only the specified value in iron loss of the lamination sheet but also the torque characteristic.

Lower iron loss using suitable fastening method. Figure 9

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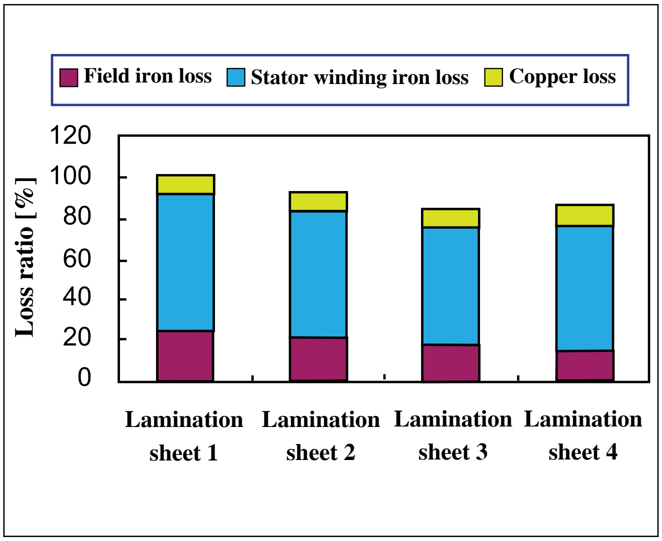

Figure 8—Relationship of lamination sheet material and loss.

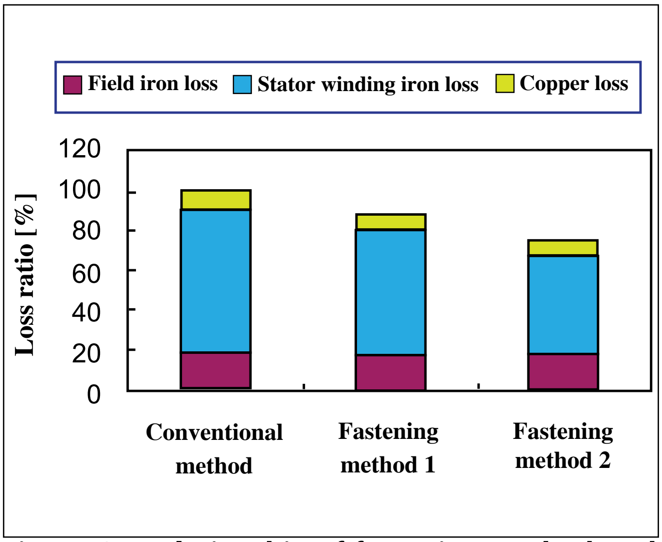

Figure 9—Relationship of fastening method and loss of (laminated) stator core.

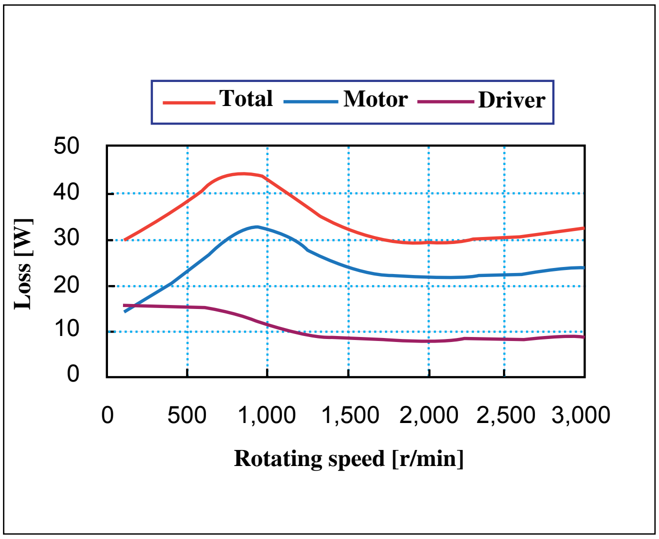

Figure 10—No-load loss of low-loss stepping motor.

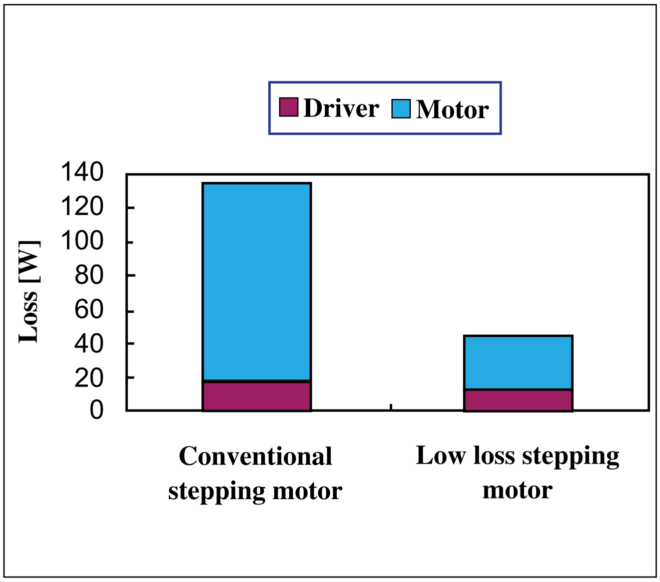

Figure 11—Loss comparison.

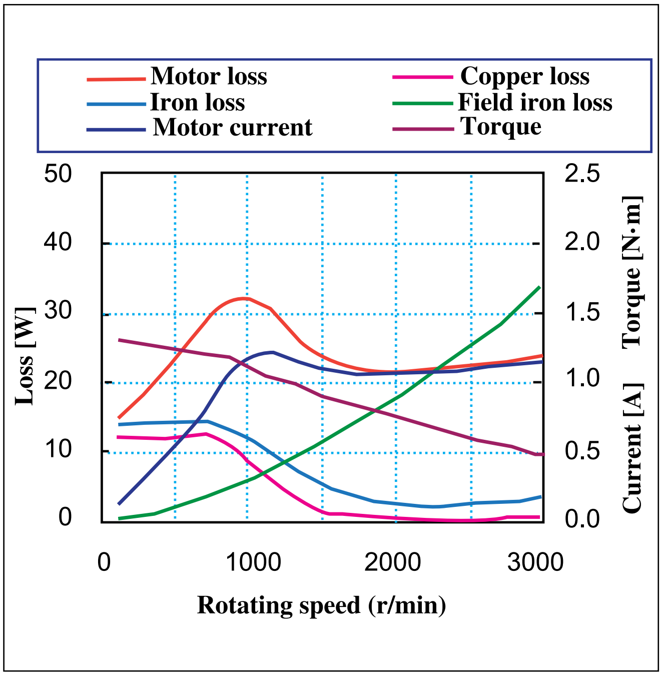

Figure 12—Motor loss of low-loss stepping motor.

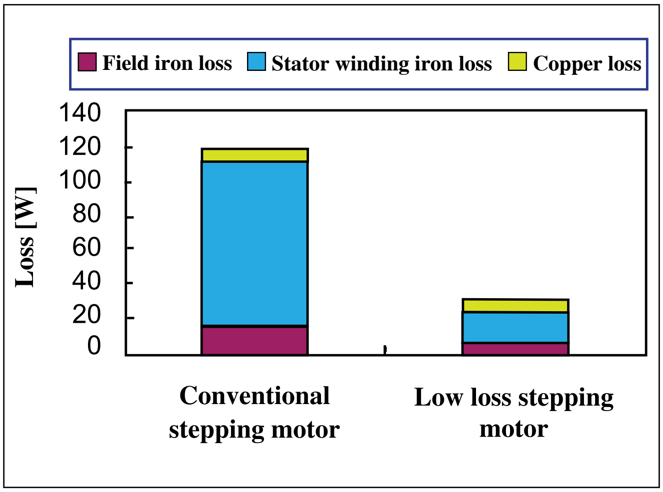

Figure 13—Comparison with conventional stepping motor.

shows the relationship of the fastening method and the loss of the (laminated) stator core; note the stator core is made of the lamination sheets to which insulation coating is given. Presently, fastening by dimples is the most common method.

The electrical insulation between the lamination sheets is broken down at the dimples. An eddy current becomes easy to flow—due to this dielectric breakdown—and the eddy current loss grows more than the value calculated by Equation 2. Figure 9 also shows the relationship of the fastening method and the maximum loss; the loss is different depending on the fastening method. The low-loss stepping motor has adopted a fastening method with a small loss.

Practical example. Figure 10 illustrates the no-load loss of a low-loss stepping motor and driver; Figure 11 shows the loss comparison with the conventional stepping motor at the rotational speed where total loss reaches its maximum value. The motor loss has decreased by 73% and the driver loss by 26% when compared with the conventional stepping motor.

Figure 12 shows the effects of separating the motor loss of the low-loss stepping motor into a copper loss and iron loss. Field iron loss exceeds iron loss at high speeds of more than 2,400 r/min, meaning that the current weakens the magnetic field—known as "field weakening."

Figure 13 shows the result of comparing loss with the conventional stepping motor at the rotating speed that maximizes motor loss. Though copper loss has increased—compared to the conventional stepping motor, because the current adjusts to enable uniform torque—stator loss is reduced by 81%, field iron loss by 73% and motor loss by 72%—when compared with a conventional stepping motor.

Figure 14 shows the temperature rise of a motor casing at maximum speed loss. At this measurement, a heat-sink equivalent to an aluminum plate in 250 mm x 250 mm x 6 mm is attached. With that, the temperature of the conventional stepping motor rose to over 60° C in about five minutes. If rotation had continued, the stator coils would burn out. Instead, the temperature of the low-loss stepping motor is less than 60 ° C and the coils will not burn out.

Loss in Positioning Operation

When a heat-sink equivalent to an aluminum plate of 250 mm x 250 mm x 6 mm is attached, the permissible dissipation of the low-loss stepping motor is about 40 W at ambient temperature. With a maximum dissipation of the low-loss stepping motor at 32 W, it is possible to drive it continuously in the above-mentioned condition.

Next up is a discussion of loss in positioning operation when a stepping motor is used mainly for positioning operation.

Loss characteristic. Figure 15 shows the relationship of the load and rotating speed. For the stepping motor, the peak value of the motor loss decreases when load increases; but the change by the load is small, while the change by rotating speed is larger.

The loss is expressed by a function of rotating speed and load torque. As such, the loss is calculated from the torque and rotating speed.

Loss calculation. Figure 16 shows the speed pattern in a typical positioning operation. This operation pattern accelerates up to rotational speed N_m in acceleration time t_1; rotates at a constant speed over time t_2; decelerates in deceleration time t_3, and stops. This operation pattern is called a "trapezoidal drive" and the area of trapezoid shows the rotation amount. Usually, applications such as inspection, assembly, etc., are done in the stop time t_4—after completion of positioning—and the following operation is begun. Time, or t_c, is from start-up to the following start-up; i.e., cycle time. When heat generation is excessive, a longer stop time for cooling is required.

Figure 17 shows the torque pattern when driven by the speed pattern in Figure 16. Torque T_L for the load torque component is necessary during a constant speed time, and acceleration torque T_a and deceleration torque T_d are necessary during an acceleration/deceleration time.

As described, stepping motor losses are impacted by rotation speed (Fig. 18).

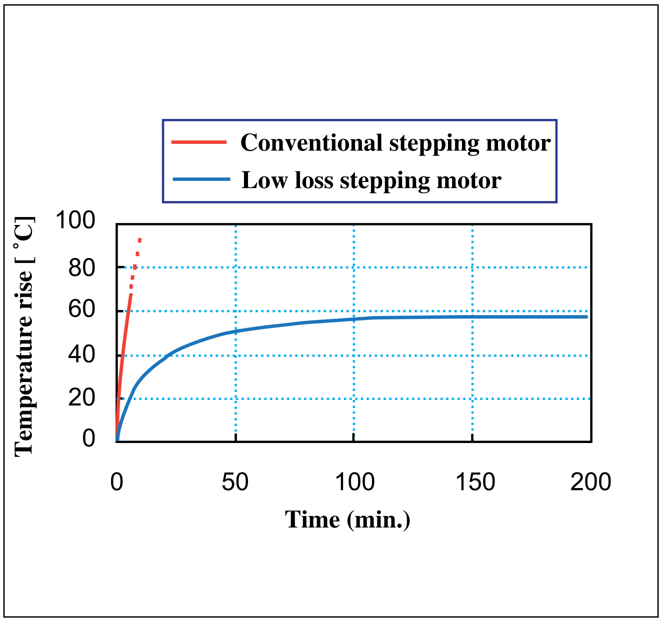

Figure 14—Temperature rise.

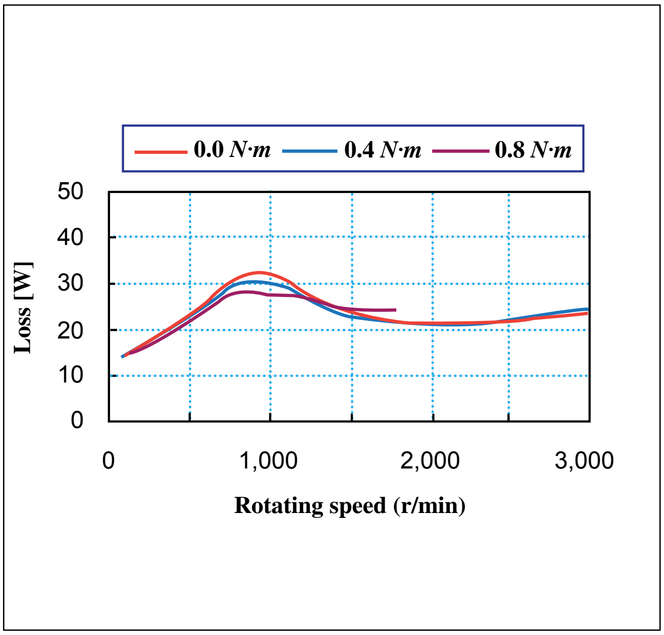

Figure 15—Loss characteristic of low-loss stepping motor.

When the instantaneous, maximum value of the loss is assumed to be $w(t)$, the average value of the loss-per-cycle is calculated by:

$$W_a = \frac{1}{t_c} \cdot \int_0^{tc} w(t)dt \qquad (10)$$

Calculation result. Motor loss is calculated when the shortest positioning operation is done with an inertial load of $J = 2.5 \times 10^{-4}$ kg• m^2 attached (i.e., 90 mm outside diameter, 5

continued

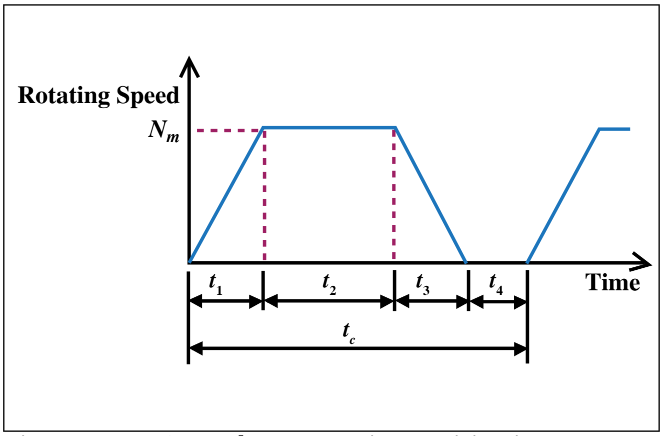

Figure 16—Speed pattern in positioning operation.

Table 2-Operation pattern

Rotation ammount (Rotation)	Acceleration/ deceleration times (ms)	Rotating speed (r/min)	Positioning times (ms)
0.1	14	400	29
0.5	30	800	68
1	40	1,000	100
2	59	1,300	152
5	100	1,800	267
10	146	2,200	419

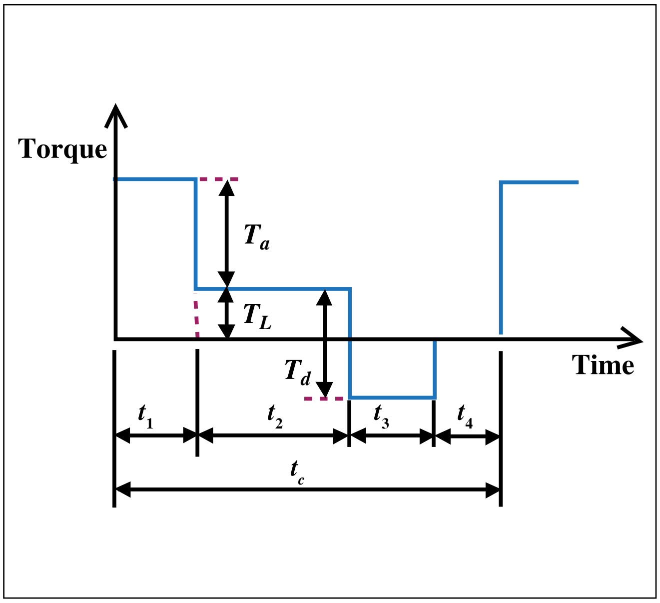

Figure 17—Torque pattern in positioning operation.

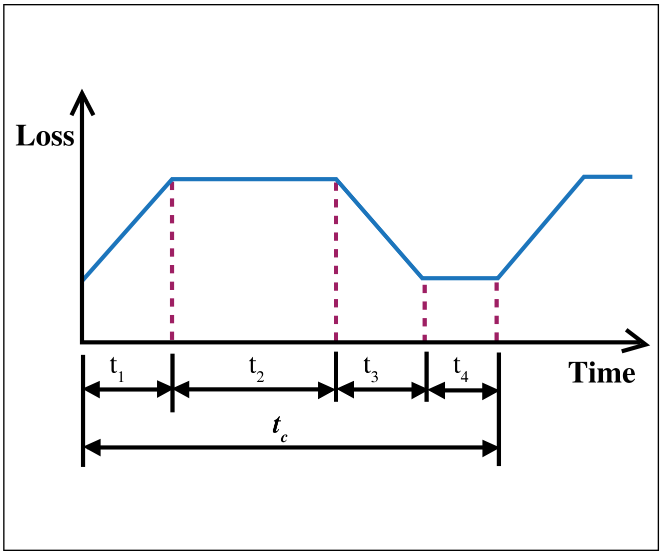

Figure 18—Loss pattern in positioning operation.

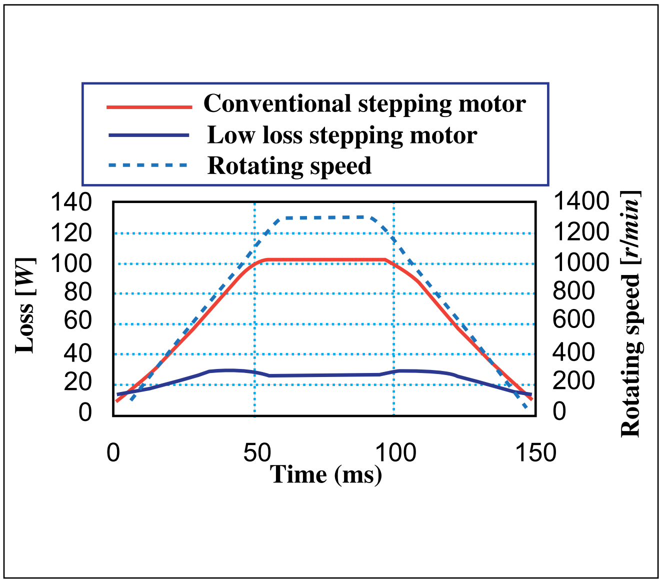

Figure 19—Calculation example.

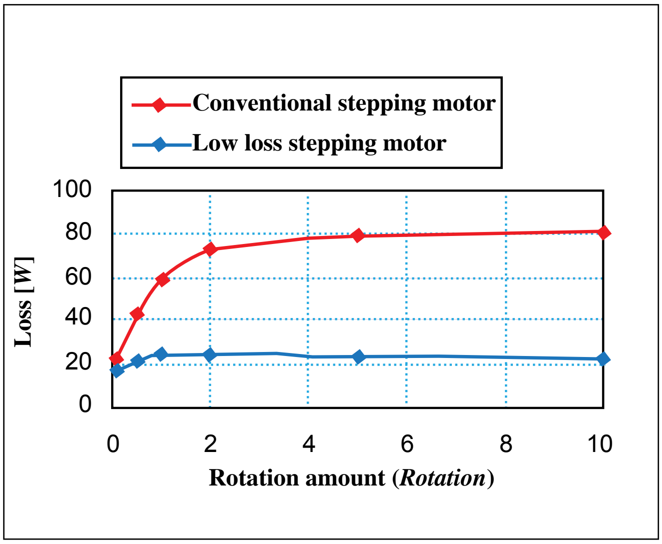

Figure 20—Relation of rotation amount and motor loss.

mm thickness and iron material). Table 2 results are derived by calculating which operation pattern/positioning time is briefest in consideration of the safety rate.

In Equation 10, the loss in each operation pattern is calculated; Figure 19 shows a calculation result of the speed pattern and loss when, for example, the rotation amount is two rotations.

Figure 20 shows the relationship between rotation amount and motor loss. When the rotation amount is 0.1, the loss difference is not significant; but when rotation amount is increased, the difference is significant.

For the conventional stepping motor, intermittent operation or fan-cooling is needed—even when a positioning operation is conducted—because the loss increases to about 80 W when the rotation amount is increased. But for the low-loss motor, a stop-time for cooling is unnecessary since the losses are only about 24 W—even when rotation amount is increased. Therefore, a continuous-positioning operation is achieved for any rotation amount.

Summary

Though the conventional stepping motor is compromised by heat-generation issues, new lower-loss-technology advances have changed the equation. It is now possible to use a stepping motor in applications requiring continuous motion at a constant speed—something unheard of until now. It then follows that applications for a stepping motor will certainly increase, as these motors are very effective for energy savings.

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www.orientalmotor.com

Yatsuo Sato *is the Oriental Motor manager of the motion control department—motor and R&D.*

November 1–3—Gear Expo. Duke Energy Convention Center, Cincinnati, Ohio. The only trade show dedicated to the complete gear manufacturing process, AGMA's Gear Expo 2011 offers efficient solutions to streamline your workflow, reduce errors and increase productivity. Browse the exhibits, compare product features side-by-side and capitalize on show-only pricing from the world's leading gear manufacturers. Registering for educational programs including the Fall Technical Meeting, Training School for Gear Manufacturing, Why Bearings Fail and How to Organize and Manage a Failure Investigation gets you free admission to the Expo. Attendees include corporate executives, design and manufacturing engineers, plant and operations managers, manufacturing personnel, purchasing managers and inspection and quality control personnel. Gear Expo offers an affordable, respected, gear-specific curriculum developed by AGMA, SME, ABMA, ASM and others to be announced. It is once again co-located with the ASM Heat Treating Society Conference and Exposition. For more information, visit *www.gearexpo.com*.

November 2–4—AWEA Wind Energy Fall Symposium. La Costa Resort & Spa, Carlsbad, California. This exclusive event sets the stage for sharing successes, strategies, and lessons-learned with wind industry peers. Giving the information and tools needed to operate in a complex and global marketplace, the 2011 AWEA Wind Energy Fall Symposium's educational program will outfit attendees with sessions that address not only industry trends and innovations, but teach you how to best communicate wind energy's benefits to external audiences. Continuing on the success of last year's event, this year's Fall Symposium will include the relaxed yet professional environment that allows for insightful and valuable interacting. Initiate, develop, and rekindle relationships with your wind industry peers through the WindPAC Reception, Networking Receptions, the 60-Minute Idea Exchange and the annual AWEA Golf Tournament. For more information, visit *www.awea.org*.

November 8–10—SMMA Fall Technical Conference. Renaissance Charlotte Suites Hotel, Charlotte, North Carolina. SMMA–the Motor & Motion Association is the manufacturing trade association for the electric motor and motion control industries. This year's technical conference theme is "Motors, Materials and Manufacturing–What Lies Ahead." More than 120 member companies include manufacturers, suppliers, users, consultants and universities will learn about industry trends and technologies, identify new supplier partners and network with other motors and drives professionals. Eli Lustgarten, senior vice president, Longbow Research, will deliver the keynote presentation, "Will the 2011 Equipment Surge Hold in 2012 as We Search for the New Normal," on Wednesday, November 9th, at 8:00 am. Markets served for the technical conference include appliance, transportation, medical equipment, office automation and computers, aerospace and industrial automation. SMMA is the voice for the motor and motion industry, providing a forum for education, communication, research and networking. To register, visit *www.smma.org*.

December 6–8—Gearbox System Design. Sheraton Sand Key Resort, Clearwater, Florida. The design of a gearbox system is much like a Hollywood movie production—the "stars" often get the recognition, while the "supporting cast" barely gets a mention! In a gearbox system, the stars are the gears and bearings. The supporting cast is everything else, including seals, lubrication, housings, breathers and other details. Explore the gearbox system supporting cast of characters at the Gearbox System Design Seminar. The treatment starts with basics, such as some history of design, the environment in which the gearbox must "live" and the loading to which the system will be subjected. AGMA member: $1,895 first registrant, $1,695 for additional registrants from same member company. Nonmember: $2,395 first registrant, $2,195 for additional registrants from same company. For more information, visit *www.agma.org*.

February 9–11—IPTEX 12. Bombay Exhibition Center, Mumbai, India. IPTEX is an exclusive exhibition focused on gear engineering and power transmission technology. The show features products and services in gears and gearboxes, gear machines and tools, linear transmission and drive systems, metrology products, software, bearing, belts and other mechanical transmission products. Supported by AGMA and organized by Virgo Communications and Exhibitions, IPTEX 12 will help attendees learn the latest trends in gear and power transmission technology and provide solutions for an array of manufacturing needs. Visitors to the 2010 show included industry leaders from the aerospace, automotive, machine tool, material handling, sugar, textile, and thermal plant industries. For registration information, visit *www.virgo-comm.com*.

March 6–8—Expo Manufactura. Cintermex, Monterrey, Mexico. The largest event in Mexico for the processing and manufacturing industries boasts more than 600 national and international brands. The exhibition offers technological solutions in aerospace, medical devices, automotive, metallurgical, aeronautics and electrical appliances. Innovation topics for the 2012 show include cloud computing, connectivity, micro and nanotechnologies, micromachining and additive processes. More than 9,000 industry professionals will visit the show looking for industry insights, new technologies and networking opportunities. For more information, visit *www.expomanufactura.com.mx*.


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Congressman Manzullo

VISITS NEW DANFOSS FACILITY

Danfoss recently hosted Congressman Don Manzullo (R-IL), local officials and community leaders for a groundbreaking ceremony for the company's new logistics facility in Loves Park, Illinois—home to the VLT Drives division. Fueled by strong growth of high-powered, energy-efficient drives, the company will relocate its receiving, shipping and warehousing operations into this new facility, which will create additional manufacturing capacity at the current location.

During his visit, Manzullo, who founded and serves as co-chairman of the House Manufacturing Caucus, also participated in a discussion with top Danfoss managers about how Danfoss VLT variable frequency drives (VFDs) are helping the environment by reducing energy consumption. He was also given a plant tour so he could learn more first-hand about the manufacturing business in his Congressional district.

In application, VFDs present a great opportunity to save significant amounts of energy and reduce the impact on the environment by reducing the dependence on fossil fuels and the need to build power plants. VFDs can typically save 15 to 40 percent of energy required to operate a motor, depending on the installation; yet, 70 to 80 percent of new industrial electric motors globally do not have variable speed drives. There are more than 3.5 million Danfoss VLT variable speed drives installed worldwide that account for a reduction in carbon dioxide emissions of 33 million tons per year.

Additionally, clean energy technologies, like those manufactured by Danfoss VLT Drives, help to create sustainable jobs. The speakers during the groundbreaking ceremony expressed a similar idea, reinforcing the importance of the impact a company like Danfoss has on the local economy.

"We are very pleased that Danfoss has chosen to keep this new warehouse facility here in Loves Park," commented Manzullo. "Our region depends on the help of businesses like Danfoss to create jobs and impact the growth of our economy. It's been a great pleasure to be here today to see first-hand the large contributions to economy, energy efficiency and environment that a U.S. manufacturing facility is making worldwide."

Illinois Congressman Don Manzullo (second from right) participated in a discussion with top Danfoss managers about how Danfoss VLT variable frequency drives (VFDs) are helping the environment by reducing energy consumption (courtesy of Danfoss).

Dunkermotoren

ACQUIRES COPELY MOTION SYSTEMS

Dunkermotoren with its headquarters in Bonndorf/ Black Forest, Germany, invests in the expansion of their drive technology product portfolio and has taken over the business of Copely Motion Systems (CMS) with its headquarters in Basildon, east of London. CMS develops and manufactures highly dynamic linear motors. "We expand our range of solutions for existing customers and market segments," said Dunkermotoren managing director Nikolaus Gräf.

Dunkermotoren currently develops and manufactures customized solutions based on rotary drives, namely brushless and brush-type DC motors with integrated power and control electronics. Within a modular system, these motors are combined with specifically developed and manufactured planetary and worm gearboxes as well as with encoders and brakes. With the acquisition of the linear motor manufacturer CMS, Dunkermotoren is determined to further develop and strengthen its favorable market position.

"Technology and product lines are logical complements. The extended product portfolio gives our globally positioned sales team the chance to offer even more comprehensive packages of service to the customer," Gräf says.

AMT and AMTDA

EXPLORE PRODUCT/SERVICE INTEGRATION

The Association for Manufacturing Technology (AMT) and the American Machine Tool Distributors' Association (AMTDA) have announced the formation of a committee to explore ways to integrate their products and services to better serve the members of both associations. This committee, which will be made up of staff and board members from

continued

both organizations, will meet and discuss strategic partnerships and a joint approach to important manufacturing issues, as well as consolidated services. The committee will begin its work in the next several weeks and is expected to report back to both organizations by year's end.


Douglas K. Woods

"It has always been my goal to find better ways to serve the manufacturing industry," said Douglas K. Woods, president of AMT. "This exploration, which we expect will lead to a very close cooperation with AMTDA, is a natural partnership that will help both organizations as they seek to advance manufacturing in the United States."

"AMTDA has always been focused on strengthening the collaboration between the product manufacturer (OEM), the local distribution firms, and the final customer," said Peter Borden, president of AMTDA. "We believe that a greater integration of our two associations' constituencies and products can further enhance the performance of each of these groups at a critical time for our industry."

Romax

AWARDED GL GEARBOX DESIGN ASSESSMENT

Romax Technology has been awarded the GL Renewables (GL) A-Design Assessment for its new range of WT2000 licensed 2 MW gearboxes. Achieving this high level of certification means that the gearbox design has passed the most stringent independent requirements set for the wind industry and is another significant achievement for Romax Technology. The WT2000 2 MW gearbox is the fourth successful Romax gearbox and driveline which includes 1.5 MW, 2.5 MW and 3 MW. Romax is continuing to work with GL to ensure its latest designs meet with the high standards set by the GL guidelines with the aim of achieving further A-Design Assessment certification for designs in the range of 750 KW to 5 MW.

The 2 MW, WT2000 certification represents the culmination of successful collaboration between Romax, AMSC-Windtec and a number of key gearbox manufacturers. The gearbox will be manufactured by Romax customers in China, Taiwan, India and South Korea and has been designed for Windtec's WT2000FC and WT2000DF wind turbine models. The Romax engineering design team has achieved compliance with the stringent guidelines set by GL, and has also delivered a gearbox design that meets the varying production criteria stipulated by each of the manufacturers within a very competitive timeframe. This has resulted in a refined, fully certified gearbox design, available in multiple regions which in turn will strengthen and improve the offering of the local supply chain.

"The WT2000 design is based on our licensable 2 MW wind turbine gearbox design," says Andy Poon, director of renewables at Romax. "Working closely with AMSC-Windtec and GL Renewables Certification has proven our design to be straightforward to certify and easy to produce in volume by many manufacturers."

NFPA

AWARDS MAJOR RESEARCH GRANT TO IOWA STATE UNIVERSITY

The National Fluid Power Association (NFPA) Education and Technology Foundation, in keeping with its vision to pursue research that has the potential to transform the fluid power industry, has awarded a major research grant to Dr. Brian Steward and the Agricultural and Biosystems Engineering Department at Iowa State University. The project, *Dielectric Spectroscope Sensor Development for Hydraulic Fluid Contaminant Detection*, will focus on developing new technology for low-cost, on-board, real-time fluid power sensors. Industry partners with an interest in this area of research are welcome to join the advisory board that will provide oversight, recommendations and guidance to the Iowa State University researchers. Participating companies will help ensure the project serves the needs of industry and will receive opportunities to commercialize the results of the research discovery. For more information, visit *www.nfpa.com*.

EPTDA

ADDS THREE MEMBERSHIPS

The European Power Transmission Distributors Association (EPTDA) recently announced three new memberships, including Simatec ag of Switzerland, Cooper Bearings Ltd. of the United Kingdom and PTM Industries Inc. of Canada.

continued

PTM Industries Inc. is an international manufacturers' partner in the Canadian market. PTM acts as a manufacturer's agent or master distributor. Operating nationally from two distribution centers (Toronto and Calgary), PTM serves almost 1,000 distributor and original equipment manufacturer customers. PTM offers manufacturers a variety of services including national sales coverage, distribution and warehousing, complete order desk support and business development strategy consulting. Established in 1984, PTM is respected for building manufacturers' brand recognition in Canada. Daniel Cotton, president, says, "PTM is proud to become a member of the EPTDA. PTM acts as a Canadian business partner for international manufacturers. As such, we are looking forward to meeting the EPTDA family, learning from respected industry professionals and building new relationships." For more information, visit *www.ptmindustries.com*.

Cooper Bearings currently offers a large range of split roller bearings with premium quality in processes and production backed by ISO 9001 and 14000, BSI and Lloyd's registration, etc. Providing a full service from design through supply, Cooper has sales/service subsidiaries in the United States, Germany, China, India and Brazil as well as a global network of prestigious national distributors. Cooper has longstanding business relationships with many existing EPTDA members, so, in the words of David Burns, divisional sales manager for the U.K. and Europe, "membership represents a logical decision while the convention itself is an excellent forum in which to meet and interact with fellow manufacturers and distributors as well as to keep abreast of trends in key markets and industrial segments." For more information, visit *www.cooperbearings.com*.

Simatec ag, a Swiss developer and manufacturer of quality industrial maintenance solutions, remains an independent, globally active family business with its head office in Switzerland (Wangen an der Aare). Globally known brand names such as Simatherm, Simatool and Simalube originate from Simatec. The development of the patented gas producing dry cell enabled the launch of the single-point automatic grease and oil lubricator, which allows clean, safe and dependable maintenance-free lubrication of bearings for the long haul. Mischa Wyssmann, CEO, says: "Simatec established itself in North America at the end of 2007, by opening an incorporated subsidiary in Charlotte, North Carolina. The American office has been an active member of the PTDA since 2009. As a result of very positive experiences and networking, Simatec ag has decided to engage with the EPTDA, PTDA's European counterpart, in the hope of fostering a similar outcome."

To date, the EPTDA has welcomed no less than 15 new member companies in 2011: four distributors, five manufacturers and six associates. With this growth, the pan-European association is also reinforcing its representation in Eastern Europe and other countries like Switzerland, France and Spain. "All these new members were officially introduced at our Annual Convention in September," states Hans Hanegreefs, executive vice president, EPTDA.

EPTDA's Annual Convention brought more than 270 key decision makers and executives of the power transmission and motion control industry, representing close to 150 companies—with an increase of distributor attendance of 40 percent. For more information, visit *www.eptda.org*.

Robotics Industries Association

UNVEILS NEW AND IMPROVED CAREER CENTER

Jobs that pay well in the robotics industry can be found on the new and improved Career Center from the Robotics Industries Association (RIA). Members of the Association asked RIA to expand the reach of its Career Center to help them find candidates. Demand for robots is up markedly this year, which spurs job openings, and recent changes to the Career Center make it one of the top ranked sources of visitors for Robotics Online. "It is encouraging how many opportunities are available in the robotics industry," says Jeff Burnstein, president, RIA. "Companies are investing in capital; especially in productivity tools like robotics. That leads to jobs, plain and simple, and we know so because our members keep telling us they have openings."

"User company memberships are up 30 percent through July and integrator memberships are up 25 percent," Burnstein says. "Integrators need skilled people, especially engineers with mechanical and electrical backgrounds. Of course experience with robotics helps."

For some, experience with robotics starts at a two- or four-year college. There are more than 40 educational institutions that belong to RIA, the most ever in one year according to association records. These schools represent the next wave of high-tech workers, and many schools are sponsored by RIA members anxious to hire students from their robotics programs. "Global pressure has forced all manufacturers to improve productivity, and the robotics industry is among the top tier of advanced technology for better quality and higher output," Burnstein says. "There are jobs for people who can apply, sell, operate and maintain robots, and RIA members are among the best companies in the world to work for."

For more information, visit *www.robotics.org*.

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3) Name:______________________ (print) Job Title/Position: ______________________

4) Signature ______________________ Date: ______________

5) Please tell us about your company:

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Company Address:______________________
____
City:______________________
State/Province:______________________
ZIP/Postal Code:______________________
Telephone:____________Fax:____________
E-mail:______________________
Co. Internet Address:______________________

6) How is THIS LOCATION involved with power transmission products? (Check all that apply)

☐ WE MAKE power transmission products (10)
☐ WE BUY power transmission products (12)
☐ WE SELL power transmission products (Distributors, sales reps. etc.) (14)
☐ WE DESIGN products with power transmission components in them. (16)
☐ Other (please describe) (15)______________________

7) Which of the following products and services do you personally specify, recommend or purchase? (Check all that apply)

☐ Actuators (30)
☐ Adjustable-Variable Speed Drives (31)
☐ Bearings (32)
☐ Belting and Belt Drives (33)
☐ Brakes (34)
☐ Clutches (35)
☐ Controls (36)
☐ Chain & Chain Drives (37)
☐ Couplings & U-Joints (38)
☐ Gears (39)
☐ Gear Drives (40)
☐ Gear Mfg. Services (41)
☐ Hydraulic Power (42)
☐ Linear Motion (43)
☐ Motors (44)
☐ PT Accessories (45)
☐ Sensors (46)

8) What is your primary job function responsibility? (Check one)

☐ Corporate Management (1)
☐ Plant Engineering (2)
☐ Design Engineering (3)
☐ Marketing & Sales (4)
☐ Manufacturing Engineering (5)
☐ Purchasing (6)
☐ Quality Control (7)
☐ Factory Automation (8)
☐ Maintenance (9)
☐ Other (10) ______________________

9) What is the principal product manufactured or service performed at **THIS LOCATION?**

____

10) How many employees are at THIS LOCATION (Check one)
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Shape-Shifters at Cal Tech Work at Perfecting Metallic Glass

alchemy n. *A process by which paradoxical results are achieved or incompatible elements combined with no obvious rational explanation; a power or process of transforming something common into something special.*
—Webster's New World Dictionary

There are no alchemists at the California Institute of Technology, but a team of research scientists at the Pasadena-based institution is doing some pretty remarkable things "transforming something common into something special."

Cal Tech researchers have developed a proprietary process—rapid discharge forming—by which metal alloys are fashioned into solid—very solid—shapes—but with the same ease and net-shape accuracy as injection-plastic molding—and—with the value-added feature of much greater strength. Or, "stronger than titanium," as one published claim has it. The material is known as "glassimetal"—a metallic glass actually invented more than a half-century ago at Cal Tech.

"Metallic glasses are materials with striking properties," says Dr. A. Lindsay Greer, a professor of materials science at the University of Cambridge in the May 13 issue of *Science*. "They are quite hard, but also rather formable like plastics—an attractive combination."

The Cal Tech team is headed up by research scientists Dr. William L. Johnson and Marios D. Demetriou, and they have launched a company—Glassimetal Technology—along with an engineering and prototype demonstration center in Pasadena.

Make no mistake—this process is still in development and, short term, its use in real-world applications will be necessarily limited. Cost, more than anything, will initially restrict widespread application use. But think of the possibilities—some niche applications already exist for metallic glass for small structural components for aircraft, or casings for such things as laptops, watches, etc.

The team's paper, "Beating Crystallization in Glass-Forming Metals by Millisecond Heating and Processing," explains the proprietary process by which they were able to surmount the intense heat/rapid speed requirement that had long been a detriment to advancing application use of metallic glass.

(courtesy Glassimetal Technology).

In a June 4 *New York Times* article by Anne Eisenberg, Johnson declares:

"We've taken the economics of plastic manufacturing and applied it to a metal with superior engineering properties. We end up with inexpensive, high-performance, precision net-shape parts made in the same way plastic parts are made—but made of a metal that's 20 times stronger and stiffer than plastic."

But Greer nevertheless cautions in the same article that metallic glasses like the zirconium-based mix used by Johnson might be less than is practically cost-effective.

"Because the alloys are expensive, these materials will probably be used mainly in niche applications where the benefits of the properties give you sufficiently better performance to justify the expense," Greer says, adding that the patented manufacturing method Johnson has developed might one day soon be affordable enough to offset the expense of raw materials.

He also expresses wonder at Johnson and his team's ability to "demonstrate extremely uniform temperatures throughout the material" in a controllable process that could ultimately have a significant impact on materials processing and manufacturing in general.

The "eureka!" in Johnson's method is that his process overcomes the long-existing drawback of metallic glasses—rapid crystallization when heated and the equally rapid, subsequent loss of the microstructure that provides their strength. According to the *Times* article, Johnson's entire process of shaping and cooling "takes only hundredths of a second—so fast that the material turns viscous and can be molded without crystallization."

As things stand, and has already been stipulated, applications for metallic glass over plastic and or powdered metal, for example, are necessarily limited due to cost. But consider: the number of people who could afford the first Winchester rifles, automobiles, personal computers, flat screen televisions, CD players, etc., etc., was by in large limited to the relatively wealthy. But American knowhow—in the form of industrial automation, for instance—soon made those products affordable for most everyone.

And if the same holds true for metallic glass, its use in common applications—gears, bearings and actuators—to name a few, could be a real game changer. It will all boil down to the "value added" paradigm. That is, at some point the "value" benefit will have to equal or surpass the "added" component of the equation.

If past American wizardry is prologue, don't bet against it. For more information: *wlj@caltech.edu.*