

Mobile Molecules

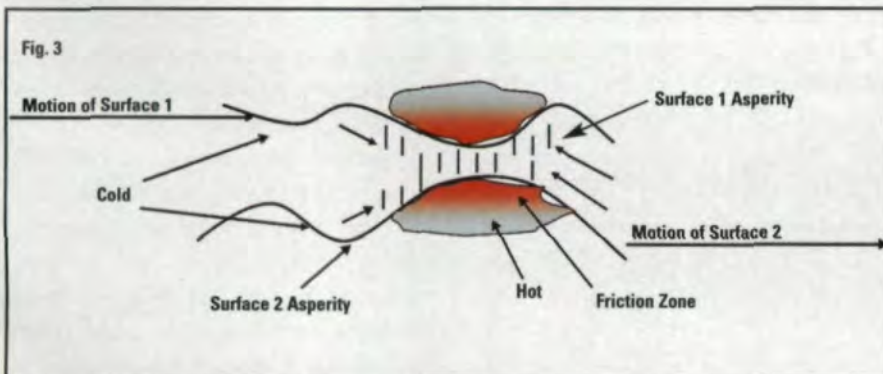
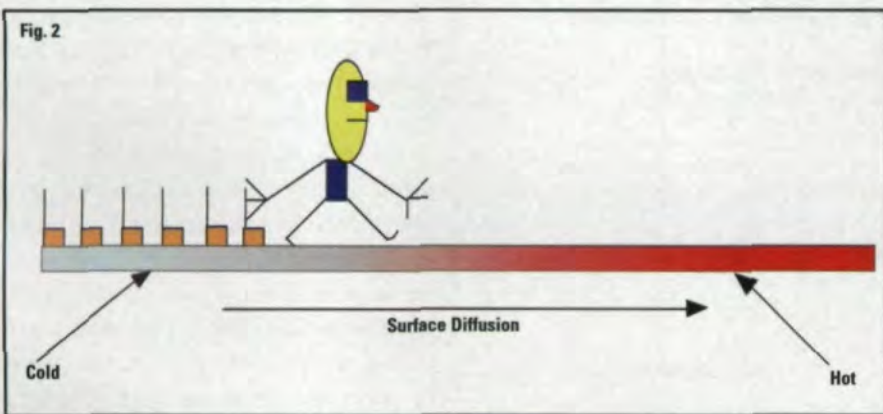
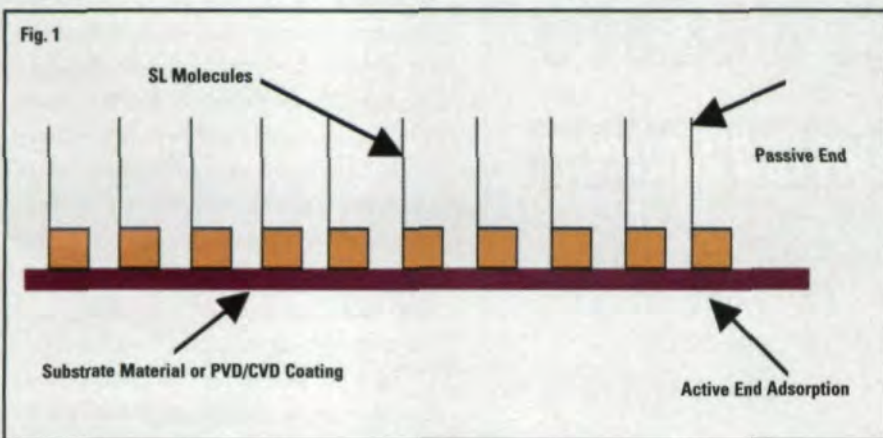
When titanium nitride (TiN) was introduced as a coating for cutting tools, the manufacturing world changed forever. The productivity gains of that and similar coatings have been so profound that coated hobs and other cutting tools are now the standard.

So where does a gear manufacturer look for the next revolution in productivity gains? At least one Chicago gear manufacturer thinks that coatings may be the answer yet again.

"We call it the magic coating," says

Yefim Kotlyar, gear technology and processing manager at Bodine Electric Co., a manufacturer of precision gears for its own fractional horsepower gearmotors, as well as for the open market.

The "magic" coating is an invisible, organic coating called SL, developed by SurfaceTech Inc. of Glenview, IL. Bodine has tested it on hobs and one worm disc cutter, with results of 150-300% improvement in gear cutting tool life compared with tools coated only with TiN. In Bodine's tests, the SL coating was applied on top of TiN.



Molecules in the SL Coating from SurfaceTech Inc. move toward the hot spots.

Welcome to Revolutions, the column that brings you the latest, most up-to-date and easy-to-read information about the people and technology of the gear industry. Revolutions welcomes your submissions. Please send them to Gear Technology, P.O. Box 1426, Elk Grove Village, IL 60009, fax (847) 437-6618 or e-mail people@geartechnology.com. If you'd like more information about any of the articles that appear, please circle the appropriate number on the Reader Service Card.

For example, one of Bodine's hobs (34 NDP, 20° NPA, 0.75" OD) cut 750 gears when coated with TiN. When the SL coating was applied on top of the TiN, the hob cut 1,500 gears, after which the test was stopped due to the order being filled. "The hob could produce more gears," Kotlyar says.

The SL coating works because it has a very unusual property: Its molecules move toward heat, providing protection to the areas that need it most, says SurfaceTech president Victor Aronov.

The mobile film coating is made up of long molecules known as radicals. One end of each molecule is positively charged, while the opposite end is neutral. When one of these radicals is brought close to a solid surface, it attaches itself (adsorbs) to the surface by its positively charged end. The neutral end, which is chemically passive, faces outside (Fig. 1). The sides of the adsorbed molecules interact with each other only weakly, so the film formed on the surface is not solid, and molecules may move freely. Since the outside ends of the adsorbed molecules are not chemically

active, the SL molecules cannot attach themselves to the workpiece surface. Thus, the molecular interaction between two contacting surfaces is diminished.

That causes considerable decrease in friction and material transfer from workpiece to cutting tool (built-up edge). The inactive end of the adsorbed molecules prohibits formation of a multilayered coating. Thus, the film thickness is restricted to the length of just one

molecule, about 30 angstroms, which does not significantly change the cutting tool geometry.

The molecules move, or diffuse, toward hot spots on a surface (Fig. 2). Because cutting tool surfaces are not smooth at the microscopic level, only the high points of the surface actually come in contact with the workpiece. During the cutting action, these high points become hotter faster. The SL molecules move

toward the hot spots, preventing direct solid-to-solid contact and providing extra lubrication where it is needed (Fig. 3).

SL is also unusual for a cutting tool coating because it's organic. "An organic coating that works for cutting tools is really an amazing thing," says Aronov. He adds that the perception has been that pressures and temperatures are too high in cutting tool applications for organic coatings. However, according to Aronov, the SL coating is stable up to 750°F.

The coating is applied by a simple dipping process, followed by a sophisticated thermal treatment. The thermal treatment is at less than 300°F, so the surface and substrate materials are unaffected, Aronov says, and its cost is compatible with prices for TiN or TiCN coating.

The SL coating has been applied and tested on a variety of cutting tools, including ceramic inserts and carbide cutting tools, Aronov says. In addition to Bodine Electric, SurfaceTech coats cutting tools for a major manufacturer of off-highway equipment.

In tests performed by SurfaceTech, the SL coating has increased tool life by as much as 1,000% when applied on top of hard CVD and PVD coatings such as TiN or TiCN, Aronov says. The tool life improvements are in addition to those gained by the underlying coating.

A major drawback of the coating is that it will not work with all cutting fluids, Aronov says. Because it's organic, some cutting fluids may cause the coating to break down or may interfere with its effectiveness. This means that some testing of the cutting fluid may have to be performed before using the coating, but SurfaceTech has developed an extensive database of compatible cutting fluids, and the company is working with the major cutting-fluid manufacturers to test additional formulations, says Aronov.

However, the coating is working well enough that Bodine is beginning to test it on other cutting tools, says Kotlyar. "We've moved it to our turning machines," he says. The results on those machines are equally impressive. "Double life at least," Kotlyar says.

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CIRCLE 119

Circle 300

ATA Merges Cutting, Testing of Large Spiral Bevel Gears

ATA Gears cuts and tests large spiral bevel gears more by sliding cutting and testing spindles around than by transferring the gears between cutting and testing machines.

ATA Gears Ltd. of Tampere, Finland, achieved that change in motion by merging the cutting and testing of large spiral bevel gears from two separate machines into a single gear generator with a testing unit.

The specially made machine consists of cutting, workholding and testing units on a T-shaped base. The cutting unit is on the T's left arm, the workholding unit on its leg, and the testing unit on its right arm.

Resting on guide plates, each unit can be slid to and from the T's intersection, so ring gear and pinion can be finish-machined and single-flank tested while minimizing the amount of switching—and distance—between units.

"New and unique." That's how Pentti Hallila, ATA Gears' general manager of sales and technical services, describes the combining of single-flank testing with large bevel gear cutting.

To produce a spiral bevel gear set, gear manufacturers usually finish-machine a ring gear on a cutting machine, then finish-machine the gear's pinion—leaving a small finishing margin. The gear and pinion are next moved

to a separate testing machine and rotated in tooth contact to see how the pinion must be finished for the set to mesh correctly.

The pinion is then transferred between the cutting and testing machines as many times as needed to create the correct contact pattern.

With its modified machine, ATA Gears slides the cutting and workholding units together to finish-machine a ring

gear. Transferring that gear to the testing unit, the company next finish-machines the pinion. ATA Gears then slides the cutting unit away from the T's intersection and slides the testing unit to the intersection so the gear and pinion can be engaged.

Rotating the workholding unit, the machine can test the ring gear and pinion's contact pattern. The cutting and testing units can be slid back and forth as



An ATA Gears employee kneels between the main parts of a specially modified machine that finish-machines and single-flank tests large spiral bevel gear sets.



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often as needed to finish the pinion so it meshes correctly with the ring gear.

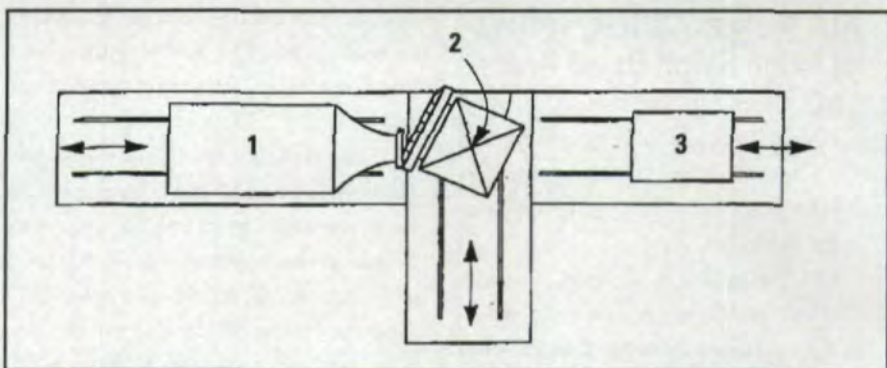
Pekka Hoikkala, ATA Gears' production engineer, came up with the idea of minimizing the transferring of gears between separate machines by merging the cutting and testing processes into a single machine. That machine is a modified Klingelberg AMK 1604 bevel gear cutting machine.

After coming up with the idea, ATA Gears applied for a patent on it and presented it to Klingelberg Söhne GmbH of Hückeswagen, Germany.

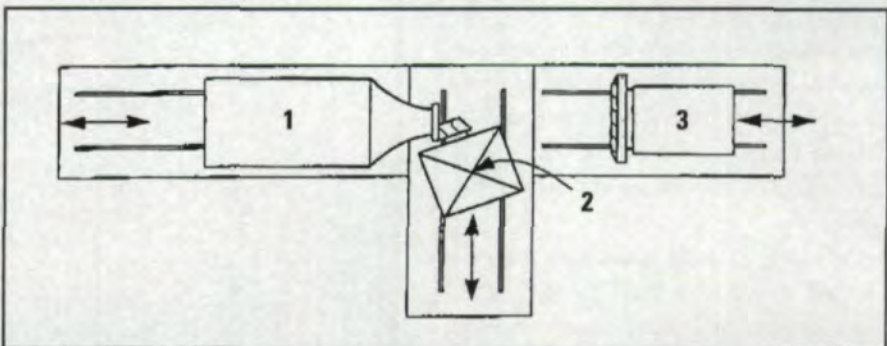
"They modified the machine accordingly," Hallila says.

He estimates that the modified machine is about 5 meters tall, 7 meters wide and 7 meters long, taking up about 50 square meters of floor space and weighing about 52 metric tons.

The machine was brought into full, online production in early 1999. ATA Gears sold more than 70 large spiral bevel gear sets that year, then again in



In its modified machine, ATA Gears uses the cutting unit (1) and the workholding unit (2) to finish-machine a large ring gear



ATA Gears next slides the ring gear away from the cutting unit, takes it off the workholding unit and places it on the testing unit (3). The company places the ring gear's pinion on the workholding unit, slides it up to the cutting unit, and finish-machines the pinion

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Klingelberg P series CNC gear checkers feature 4-axis measuring technology to inspect parts up to

2000. Hallila defines a large spiral bevel gear—that is, a ring gear—as one with a diameter greater than 40 inches.

Using the modified machine, ATA Gears can manufacture spiral bevel gears up to 100 inches in diameter.

Other companies—Amarillo Gear Co. of Amarillo, TX; Brad Foote Gear Works Inc. of Cicero, IL; and Foote-Jones/Illinois Gear of Chicago—can manufacture such gears, cutting and test-

ing them on separate machines.

Such large spiral bevel gears are used by businesses involved in heavy engineering for crushers and in marine equipment for propelling ocean-going ships and offshore vessels, like drilling rigs. The gears are also used in coal mills for pulverizing coal and cement mills for pulverizing cement.

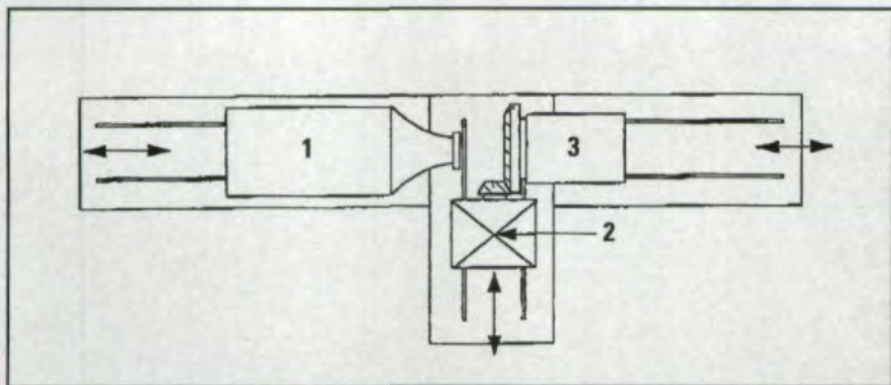
ATA Gears started making its large spiral bevel gears in 1998.

“The market was going to larger and larger units,” Hallila explains. He says the trend was true regardless of industry, but he adds the markets for large spiral bevel gears are very limited.

“They are a part of our daily operation,” Hallila says about the large gears, “but they are special ordered.”

ATA Gears created the modified machine, changing from transferring large gears between cutting and testing machines to sliding spindles around, to save time and increase productivity.

Circle 302



ATA Gears then slides the cutting unit away from the pinion and slides the testing unit up, to test the gear set's contact pattern. The company can slide the cutting and testing units back and forth until the contact pattern is correct.

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