Thermosets on the Rise

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A journal bearing is a cylindrical component that rides on a rotating shaft, floating on a layer of oil or grease. Larger journal bearings, with diameters to 16 in., are common in mills. For example, on heavy metalworking equipment, the largest of these bearings allows the spinning of rollers that shape and transport materials such as steel and aluminum.

Metal journal bearings are the classic, and for good
reason — they're a strong, relatively durable, and familiar component. But as material science has progressed, so too has its application in power transmission components. Now, more journal bearings are made of synthetics.

One variation is reinforced thermosets. Thermoset tubing materials used for bearings consist of cloth-reinforced resin. The composite resins start out as liquid polymers, but once exposed to thermal energy, three-dimensional covalent bonds form between polymer molecules and the material solidifies, creating an irreversible cross-linking. This cross-linking creates a rigid molecular structure that maintains physical properties. A basic thermoset composed of medium-weave cotton reinforcement and phenolic resin is most common.

But in addition to standard formulations, custom thermosets can be designed to meet specific bearing-related design requirements. Tubing materials come in different types and offer physical characteristics able to support high compressive loads and extend bearing life.

Goodbye oil

Thermoset composites can reduce or even eliminate the need for journal bearing lubrication. How? Some thermosets include self-lubricating modifiers such as graphite powder and Teflon that minimize the bearing and shaft wear that results from contact.

Self-lubricating thermosets are useful for:
• Bearings in hard-to-access locations. To lubricate some journal bearings, operators might otherwise have to take equipment apart.
• Bearings that can't be lubricated often enough. In off-road trucks stationed on jobs for long periods, selflubricating bearings eliminate costly downtime for maintenance.

• Applications that ban lubricants. Oil and grease are considered contaminants and not allowed in some equipment used in food and medical industries.

The edge over metals

Metal bearings can cause operational, maintenance, and repair problems. They're more difficult to machine, which slows production and increases cost. Corrosion is another issue. Also, the high temperatures and pressures of industrial equipment can bond steel, bronze, and brass bearings to a shaft. So when the time comes to remove the bearing, it must be cut off the shaft with a torch. This causes damage that requires plant personnel to remove the shaft and reface it so that its surface is smooth enough for the new bearing.

Thermoset tubing materials used in large journal bearings, such as these, can carry high compressive loads.

The cost of removing and refacing a shaft can be 10 times that of replacing the bearing — and companies can incur these costs twice a year as metal journal bearings wear out. In addition, designers may be forced to keep spare shafts in inventory if equipment downtime for shaft repairs is unacceptable.

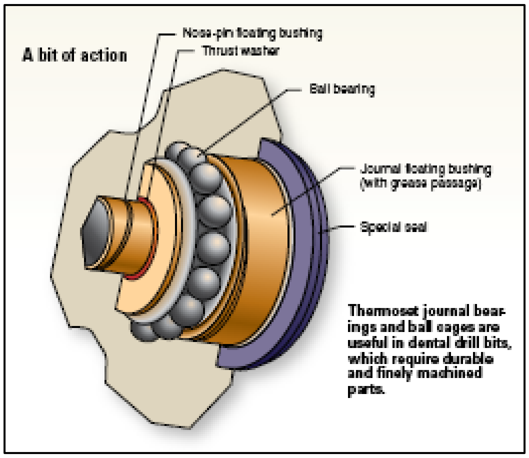
Unlike metal bearings, thermoset bearings don't bond to steel shafts. This makes them relatively easy to remove in a fast process that usually causes no shaft damage. Besides complicating the task of replacing journal bearings, metals cause problems by conducting electricity, which flows between contacting metal parts, causing corrosion and more frequent repairs and part replacement. In contrast, thermoset composite tubing materials are electrically insulated, which allows them to provide an electrical barrier between metal parts that prevents the transfer of potentially damaging electric current and static charges.

With a lower tensile and flexural modulus than steel and other metals, thermoset composite materials do a better job of damping vibrations.

Ball-bearing cages

Journal bearings aren't the only components manufactured from thermosets. Ball-bearing cages, used to separate steel balls to prevent wear, also benefit from the characteristics of thermosets. These cages, on bearings in small and medium-size motors, aircraft, and heavy off-road trucks, extend machine life. There is a difference in the thermosets used for cages. Because these bearing parts require fine machining, composites with cotton cloth substrates of a finer weave are used. This allows the material to be machined to very tight tolerances, making it suitable for bearing cages that must meet tolerance specifications to ±0.001 in.

Where bearing cages require machining that's even more precise than that — in the small electric motors that drive dental drills, for example — thermosets with an extra-fine linen substrate are more suitable. The finer composition allows machining of intricate cage features that, when finished, can hold ball bearings about half the size of a pencil eraser.



Thermoset journal bearings and ball cages are useful in dental drill bits, which require durable and finely machined parts.

Here's why:

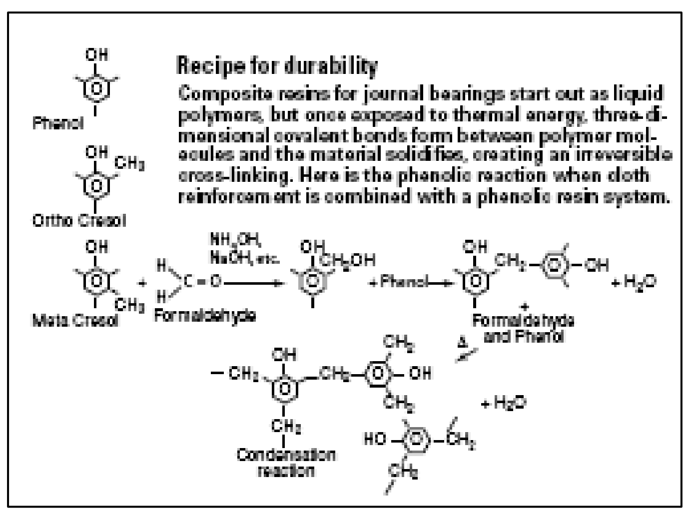
• Good dynamic frictional properties. The normal wear of thermoset composite journal bearings lowers the material's coefficient of friction. Therefore, thermoset journal bearings that have been in use generate less heat than metal bearings.

• Unlike metals, which are notoriously susceptible to corrosion, thermoset composites stand up well to water and other coolants used to dissipate heat generated by shaft rotation.

• Easier machining. Thermoset composite tubing materials can be machined up to four times faster than commonly used bearing metals such as steel, brass, and bronze. These metals are harder than thermoset materials, so they must be machined more slowly, to keep them from overheating and to prevent damage to machine tools used.

Thermosets vs. thermoplastics

Thermoplastic journal bearings are another option. They don't corrode like metal types. However, most low-end nylons and acetal thermoplastics don't have the strength to handle the high compressive loads common in bearing applications. In addition, the walls of journal bearings made of many thermoplastics are susceptible to creep when bearing temperatures exceed 70º C, so their deformation can have a significant impact on end products. For example, a thermoplastic bearing might support a roller used in the production of aluminum foil that's supposed to be 0.003 in. thick. Here, bearing creep can cause the roller to move slightly, allowing foil thickness of 0.0035 in. instead of 0.003 in. — a material waste of almost 15%. What's more, relatively large thermoplastic creep can occur rapidly — sometimes necessitating bearing replacement just weeks after installation. In contrast, the creep rate for thermosets is about 10% that of nylons and acetal thermoplastics, so thermoset journal bearings can last months or even years longer.



Recipe for durability
Composite resins for journal bearings start out as liquid polymers, but once exposed to thermal energy, three-dimensional covalent bonds form between polymer molecules and the material solidifies, creating an irreversible cross-linking. Here is the phenolic reaction when cloth reinforcement is combined with a phenolic resin system.

High-end engineering thermoplastics are a different story. They're excellent even in heavy bearing applications. And when bearings must handle extremely demanding conditions — for example, a load of 10,000 psi and a shaft speed of hundreds of feet per minute — these thermoplastics are often the only suitable option. (Here, thermosets may not work unless generated heat is dissipated by water or another coolant.) However, thermoplastic materials are up to 10 times more expensive than thermoset composites, as the chemicals used to manufacture a bearing out of engineering thermoplastic are much more expensive than thermoset materials. And the final bearing may not provide a longer service life than a similar thermoset bearing.

In fact, it’s often less expensive to use a thermoset bearing rigged with a cooling system than it is to install thermoplastic journal bearings. A foot-long thermoplastic journal bearing with an inch-thick wall and 8-in. diameter can cost as much as $20,000. A thermoset bearing with the same dimensions costs only about $1,000, and a cooling system may add only an additional $1,000 or so if the plant has onsite cooling water. As designers become more comfortable with the idea that higher-cost bearings don’t necessarily protect million-dollar machinery any better than other designs, thermoset bearings are replacing thermoplastics in many of these fast, have applications.