WITH FORTY YEARS OF EXPERIENCE, IGUS® HAS A COMPREHENSIVE DATABASE ON THE TRIBOLOGIC PROPERTIES OF POLYMERS.

Why plastic bearings outperform metal

Plastic bearings cost and weigh less than their metal counterparts. And they often run longer in harsh environments and under adverse conditions.

Contents

Plain bearings molded of plastic are often an economical replacement for needle, ball, and plain metal bearings. To a certain extent, though, plastic bearings face an uphill battle for respect among the engineering community.

One reason is the erroneous mind-set among some engineers that plastic is inferior to metal. Others cling to the notion that high-priced engineered polymers are a must for plastic bearings. The fact is, low-cost materials with excellent strength and thermal properties let inexpensive plastic bearings outperform their metal counterparts in many rotary, oscillating, and linear-motion applications. For example, self-lubricating plastic bushings routinely deliver a longer service life than oil-impregnated sintered bronze bearings, with cost savings up to 40%. And today, plastic

MATERIALS-ENGINEERING ADVANCES let plastic bearings match or exceed the performance of metal bearings in many high-load applications. And plastic bearings weigh less, need no lubrication, and better tolerate dirt, chemicals, and salt water.

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plain bearings are available off-the-shelf in many designs, sizes, materials, and even colors to meet wide-ranging performance demands.

Engineers with little experience with plastic bearings might be reluctant to put an expensive machine at risk with low-cost components they know nothing about. Many users only turned to plastic bearings out of desperation when all else failed. But with growing recognition that plastic bearings often outlast metal versions, need no lubrication, and offer the potential to cut size and weight, plastic bearings increasingly are the preferred choice in many applications.

Plastic plain bearings are available in many designs, sizes, materials, and colors to meet wide-ranging performance demands.

Plastic's advantages

Plastic bearings typically consist of a thermoplastic alloy and solid lubricants with a fiber matrix often added for creep resistance and strength. The most common low-cost materials are nylon, ultrahigh-molecular-weight (UHMW) polyethylene, and Teflon. High-performance engineered plastics such as Vespel, Torlon, and PEEK are sometimes used for extremely high loads and temperatures, but these can be cost prohibitive. Probably the most significant change in plastic bearings over the last few years is increasingly higher load and temperature capabilities. But the primary advantage plastic holds over metal bearings remains the ability to operate dry without additional lubrication.

All bearing constituents — the thermoplastic, fiber matrix, and lubricants — have excellent antifriction and low-wear characteristics that produce a self-lubricating effect. This is especially critical at initial start-up. A lubricant film has not yet formed and the bearing begins operation dry. This can accelerate wear in metal bearings, but plastic bearings homogeneously impregnated with solid lubricant run "lubricated" from the start.

As soon as a loaded plastic bearing moves, microscopic bits of solid lubricant and thermoplastic abrade to smooth the shaft surface. The material fills shaft imperfections and provides an optimum surface for continuous lubrication.

This minimizes slip-stick conditions and wear, and frequently increases operating life compared with plain-metal, ball, and needle bearings. Dimensional changes to the bearing are essentially nonmeasurable, and abrasion decreases rapidly following startup and becomes negligible in continuous operation. In addition, the fiber-reinforced materials maintain the bushing's strength and resistance to high forces and edge loads.

Most plain bearings, on the other hand, are oil-filled, sintered bronze that requires a separate lubricating film or coating. Sintered-bronze bearings rely on capillary action to create a lubricating oil film. Critically, however, high speed and rotational motion are both required to draw the oil out and maintain a full film of lubricant. Shaft oscillation, slow speed, and intermittent use can all inhibit this process. If movement stops, the oil on the bearing surface dries up. This can lead to higher friction and squeaking. High temperatures can also break down the oil.

Also, a lubricated shaft presents problems. One is that the bearing pushes the oil along the shaft as it moves, eventually depleting the oil film unless regularly lubricated. In actual practice, bearing lubrication is usually haphazard at best, and the result is shorter bearing life.

The other problem is that an oil film on the shaft acts as a magnet for dust, dirt, and airborne debris. This can clog the bearing or contaminate a product or process, particularly in food or medical settings. Plastic bearings solve these problems by first, requiring no lubrication. Then even under extremely dirty conditions, particles simply embed into the wall of a plastic bearing with little effect on performance.

Plastic bearings offer other advantages as well, including excellent chemical compatibility that bronze bearings cannot match. Most types resist corrosives such as hydrocarbons, alcohols, and alkaline solutions. Teflon bearings stand up to virtually all chemicals including etching acids. FDA-approved materials permit contact with food and pharmaceuticals.

Plastic bushings are usually underestimated at high temperatures. Some low-cost bearings operate continuously at temperatures approaching 500°F and withstand peaks to 600°F; low-temperature limits are generally to –40°F. Engineered plastics have an even wider temperature range.

Plastic bearings also run quietly and absorb or damp mechanical vibrations. The so-called mechanical loss factor, an indicator of vibration-damping capability, is up to 250 times

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MILLIONS OF TIMES OVER.
— AND FORGET IT.

higher than that of plain-metal bearings. Consequently, plastic versions typically run quieter, particularly compared with antifriction ball and needle bearings.

Predictable lifetime

One drawback in the past was the general inability to accurately predict the life of plastic bearings. New software programs from some of the major bearing manufacturers now overcome these concerns. For instance, the DryLin® and iglide® Expert System service-life calculators from igus Inc., East Providence, R.I. (www.igus.com) are handy tools for predicting plastic-bearing life under various operating conditions.

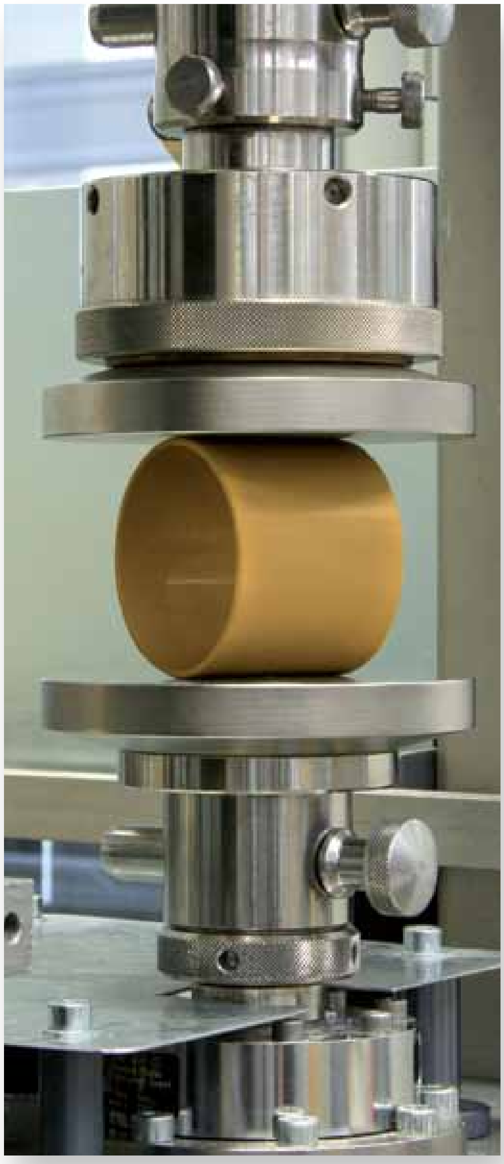
Users enter data such as the proposed bearing dimensions; maximum loads and exposure to shock or edge loading; whether motion is rotating, linear, pivoting, or a combination of these; speed of motion, and whether it's intermittent or constant; operating temperature range; chemical exposure, the mating surface; and acceptable limits on bearing wear.

It also asks for details such as whether lubrication is possible, if the bearing is exposed to dust or other contaminants, needs to be electrically conductive or insulating, and used in food processing, outdoors, under vacuum conditions, or exposed to radiation.

Results of the calculations include life in hours and travel distance for various suitable products. Other results include wear rate, PV (pressure-velocity) calculations, price/life data, and overall "suitability" ratings.

Calculations are based on an extensive tribological test database and have been verified with thousands of hours of actual testing. Results are deemed to be quite accurate.

Of course, experts always encourage testing a selected bearing in the proposed application before releasing a machine to the market. Most plastic-bearing manufacturers willingly supply test samples. But experience plays a major role in selecting the best material and design for a given application, so getting engineering assistance from a bearing manufacturer is almost always prudent. Often there is no one material or style that best suits an application, and selection involves tradeoffs between competing performance characteristics.



HEAVY-DUTY Q2 BUSHINGS from igus withstand radial loads exceeding 11,000 psi. They offer long service life in heavy-duty pivoting applications.

Common misconceptions

In addition to the material, a basic difference between thin-walled plastic bushings and thick-walled bronze bushings is thickness. The wall thicknesses of standard bronze bushings range between 0.0625 and 0.156 in. In comparison, plastic bushings have walls typically from 0.0468 to 0.0625-in. thick.

Thin walls offer some advantages that let plastic bushings perform as well as, if not better than, thick-walled bushings. For example, thinner walls are better for heat dissipation. Heat buildup can accelerate wear on a bushing, so it is critical that heat dissipates through the shaft and housing. With thick-walled bronze bushings, heat buildup is much more likely.

Better heat dissipation equates to higher PV values — a measure of performance capability. Higher PV ratings let bushings handle higher speeds and loads.

In addition, thin-walled plastic bushings can hold tighter tolerances and are less likely to deform, which can be common with thicker-walled bushings. Finally, thin-walled plastic bushings are well suited for applications where weight and fuel economy are an issue. Typical examples include racing bikes, snowmobiles, automobiles, and motorcycles.

Despite the performance advantages, several misconceptions may make engineers reluctant to take full advantage of the benefits of thin-walled plastic bushings:

1. Durability. One misconception is that thin-walled plastic bushings are not as strong or durable as thick-walled bronze bushings. It is important to remember that the wall thickness of either bushing does not directly correlate to its strength. Other more-important factors engineers should take into consideration include the bushing's weight, coefficient of friction, and wear resistance.

2. Surface pressure. Another mistake is to assume the thin wall of press-fit plastic bushings will affect the surface

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pressure. Actually, the surface pressure of a press-fit bushing, typically rated in pounds per square inch (psi), is determined by the load divided by the surface area it acts on:

$Ps = L/(D \times l)$

where Ps = surface pressure, psi; L = load, lb; D = inside diameter, in.; and l = bushing length, in. Whether one is using a thin-walled plastic bushing or a thick-walled bronze bushing, wall thickness has no bearing on surface pressure.

3. Life. A third misconception is that thin-walled plastic bushings have shorter lives than their thick-walled bronze counterparts. It seems reasonable to assume that because a plastic bushing has a thinner wall and less material, it will not last as long as a thick-walled bronze bushing. But it's wrong. The thin wall of a plastic bushing better dissipates heat, which helps slow wear.

PLASTIC BUSHINGS AND BEARINGS are used in gaming seats to handle roll, pitch, and heave movements. The wear-resistant bearings dampen vibrations and run silently without lubrication.

Bronze bushings are designed with thicker walls to compensate for wear. But even with the added material, the bushing surface still wears under certain conditions. In high-rotation applications, continually relubricating the bushing helps prevent this wear. But if a bronze bushing sees other types of motion, such as low-speed rotation or back-and-forth oscillation, it may experience inordinate wear that increases clearance between the shaft and bearing. This, in turn, can lead to a number of problems, such as a loss of accuracy, higher friction, excessive noise, and premature failure. It is important to remember that wear depends on the bushing material and not wall thickness.

Successful applications

Plastic bushings have already replaced sintered bronze bearings in thousands of applications from a wide range of different industries, including agricultural machinery, lawn mowers, medical equipment, fitness equipment, pumps, and valves.

They're especially important in food and packaging equipment that handles sensitive products and must meet high standards of cleanliness and hygiene. And, of course, every manufacturer and user demands competitive costs and trouble-free performance.

To that end, engineers are increasingly turning to plastic bearings for packaging tasks ranging from cartoning and filling, to palletizing, labeling, and inspection. Plastic bearings are inherently corrosion resistant and maintenance-free, making them cost-effective replacements for most ball bearings. They are also self-lubricating and operate oil-free — a major advantage because FDA regulations prohibit most lubricants for sanitary reasons, and even approved lubricants attract dust and dirt, which can eventually cause bearings to seize.

For instance, a pasta manufacturer recently replaced V-grooved, track-guided rollers on its cartoning machines with plastic plain bearings. The machines, which operate 24/7, use a shuttle bucket to carry and unload 1-lb portions of pasta. The bucket travels 18 in., 240 times a minute, to keep up with the machine's load station.

Despite the rapid cycling and extreme acceleration, the plastic bearings last more than three times longer than the previous roller bearings and have reduced annual repair costs by $7,800. And the lube-free bearings cannot contaminate the pasta or packaging.

Replacement, if necessary, takes less than 2 hr — in contrast to the full day of downtime it takes to rebuild just one set of rollers. And, as an added benefit, the company reports vibration issues have been eliminated and the machines run much quieter.

In another case, an OEM turned to plastic bearings for equipment that packages flour, sugar, and various types of pet food. The machines operate around the clock and are expected to last 20 to 30 years. To meet the demanding durability requirements, the company's engineers specified plastic linear bearings on guide rods in the machine's trimming and pressing stations.

The linear bearings' aluminum adapter fits over a plastic liner. The beefed-up construction lets them carry up to thirty 50-lb bags/min on each machine, 43,200 times per day.

The dry-running bearings are unaffected by flour or sugar dust that gets stirred up during packaging. The bearings will not contaminate the food or get clogged with flour and sugar, unlike bearings that require constant lubrication.

Plastics bearings have excellent strength, good thermal properties, and need no external lubrication. And the low-cost, lightweight bearings deliver long life despite exposure to harsh chemicals, dust, dirt, and other contaminants. With advances in polymer engineering, plastic bearings now outperform metal bearings in many applications.