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DESIGN AND ANALYSIS OF PA66 WITH MOS2 USED IN VEHICLE PARTS USING ANSYS

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Abstract

Polyamides (PA) of Glass fiber (GF) with Molybdenum disulfide (MOS_2) are used in various types of friction and wear reduction application of vehicle parts. Self lubricating composites like MOS_2 exhibits advanced mechanical properties and abrasive resistance. In this work, comparative analyses of various material properties are studied and developed components which are having similar requirements in the vehicle parts. There are three materials are identified for the comparative analysis. 1. Power metallurgical sintered parts 2. Polyamides Grade 6 (PA6) without adding fillers. 3. Polyamides with Glass filled (PA 66) fibers and MOS_2.

Introduction

Thermoplastics have replaced metals in many light duty load bushings applications because of their lightweight, economic fabrication and good chemical resistance. The increase in use of polymers is due to the low coefficient of friction when compared with metals because of low interfacial adhesion energy. The mechanical strength and wear resistance of polymers largely determine the suitability of these materials for applications like bushings, gears, bushings, cams, etc., Further more polymer gears and bushings can accommodate shock loading, shaft misalignment and bending better than the metal parts.Polyamides (PA or Nylon) and polyacetal (POM or Delrin) are the widely used thermoplastic polymers for engineering applications. Sintered bronze bushing function best on very hard, expensive, precision ground shafts in contrast, plastic bushings can run on all types of shafts. Plastic bushings are usually underestimated at high temperatures; yet short-term temperatures over 572^o Fahrenheit and long-term temperatures of up 482^o Fahrenheit are possible. Their dry-running nature means dirt particles do not stick to the surface, but instead deflect off it. For this reason, optimal performance can be maintained even in extremely dirty environments.

Need for Alternate Materials

Plain bushings molded of plastic are often an economical replacement for metal bushing. To a certain extent, though, plastic bushings face an uphill buttle for respect among the engineering community. One reason is the erroneous mind-set among some engineers tat plastic is inferior to metal. Others cling to the notion that high priced engineered polymers are a must for plastic bushings. The fact is low-cost materials with excellent strength and thermal properties let inexpensive plastic bushings outperform their metal counterparts in many rotary, oscillating, and linear-motion applications. Self- lubricating plastic bushings routinely deliver a longer service life than oil impregnated sintered bronze bushings, with cost savings up to 40%. And today, plastic plain bushings 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 bushings might be reluctant to put an expensive machine at risk with low-cost components they know nothing about. To put an expensive machine at risk with low-cost components they know nothing about. Many users only turned to plastic bushings out of desperation when all else failed. But with growing recognition that plastic bushings often outlast metal versions, need no lubrication, and offer the potential to cut size and weight, plastic bushings increasingly are the preferred choice in many applications. Materials-engineering advances let plastic bushings match or exceed the performance of metal bushings in many high-load applications. And plastic bushings weigh less, need no lubrication, and better tolerate dirt, chemicals, and salt wate, Plastic bushings 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, 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 bushings over the lost few years is increasingly higher load and temperature capabilities. But the primary advantage plastic holds over metal bushings remains the ability to operate dry without additional lubrication. All bushings constituents — the thermoplastic, fibre 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 bushings begin operation dry. This can accelerate wear in metal bushings but plastic bushings homogeneously impregnated with solid lubricant run “lubricated” from the start. As soon as loaded plastic bushings moves, microscopic bits of solid lubricant and thermoplastic abrade to smooth the shaft surface. The material bills 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 and plastic bushings. Dimensional changes to the bushings are essentially no measurable, and abrasion decreases rapidly following start up and becomes negligible in continuous operation. In addition, the fibre -reinforced materials maintain the bushing’s strength and resistance to high forces and edge loads. Most plain bushings, on the other hand, are oil—filled, sintered bronze that requires a separate lubricating film or coating. Sintered-bronze bushings 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 these process. If movement stops, the oil on the bushings 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 bushing pushes the oil along the shaft as it moves, eventually depleting the oil film unless regularly lubricated. In actual practice, bushings lubrication is usually haphazard at best, and the result is shorter bushings 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 bushings or contaminate a product or process, particularly in food or medical settings. Plastic bushings solve these problems by first, requiring no lubrication. Then even under extremely dirty simply embed into the wall of plastic bushings with little effect on performance. Plastic conditions, particles bushings offer other advantages as well, including excellent chemical compatibility that bronze bushings cannot match. Most types resist corrosives such as hydrocarbons, alcohols, and alkaline solutions. Teflon bushings 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 bushings 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 bushings 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.

Types of Plastics

- **PP** - Polypropylene is extremely chemically resistant and almost completely impervious to water. Black has the best UV resistance and is increasingly used in the construction industry. Application: automotive bumpers, chemical tanks, cable insulation, battery boxes, bottles, petrol cans, indoor and outdoor carpets, carpet fibres.
- **PVC** - Poly-vinyl-chloride has good resistance to chemical and solvent attack. Its vinyl content gives it good tensile strength and some grades are flexible. Colored or clear material is available. Application: automobile instruments panels, sheathing of electrical cables, pipes, doors, waterproof clothing, and chemical tanks.
- **ABS** - Acrylonitrile - butadiene-styrene is a durable thermoplastic, resistant to weather and some chemicals, popular for vacuum formed components. It is a rigid plastic with rubber like characteristics, which gives it good impact resistance. Application: car dashboards, covers.
- **PA** - Polyamide is known as nylon6.6 or nolon6. Bothe these nylons have high resistance to abrasion, low friction characteristics and good chemical resistance. They alos absorb water easily and components is wet or humid conditions will expand, precluding their use in applications were dimensional stability is required. Application: gears, bushes, cams, bearings, weather proof coatings.
- **PS** - Polystyrene is very popular, ease to manufacture, but has poor resistance to UV light. Application: equipments housings, buttons, car fittings, display bases.
- **PE** - Polyethylene has good chemical resistance. Two types are used low density Polyethylene (LDPE) and high density polyethylene (HDPE) can be manufactured in a range 30 of densities. Application: glass reinforced for car bodies, electrical insulation
- **POM** - Polyoxymethylene (also known as polyacetal or polyformaldehyde) has big stiffness, rigidity and excellent yield, which are stable in low temperatures as well. Very good chemical and fuel resistance. Application: interior and exterior trims, fuel systems, small gears.
- **PC**- Polycarbonate has good weather and UV resistance, with transparency levels almost good as acrylic. Applications: security screens, aircraft panels, bumpers, spectacle lenses, headlamp lenses.
- **PMMA** - Acrylic is more transparent than glass, has reasonable tensile strength (shatter proof grades are available) and good UV and weather resistance, high optical quality and surface finish with a huge colour range. Application: windows, displays, screens.
- **PBT** - Polybutylene terephthalate has good chemical resistance and electrical properties, hard and tough material with water absorption, very good resistance to dynamic stress, thermal and dimension stability. Easy to manufacture - fast crystallization, fast cooling. Application: foglamp housings and bezels, sun-roof front parts, locking system housings, door handles, bumpers, carburetor components.
- **PET** - Polyethylene terephthalate has similar conditions as PBT, good thermal stability, good electrical properties, very low water absorption, excellent surface properties. Application: wiper arm and their gear housings, headlamp retainer, engine cover, connector housings.
- **ASA** - Acrylonitrile styrene acrylate material has great toughness and rigidity, good chemical resistance and thermal stability, outstanding resistance to weather, aging and yellowing, and high gloss. Application housings, profiles, interior parts and outdoor applications.

Advantages of Plastic Bushings

Plastic bushings constitute the step from a simple plastic bushing to a tested, predictable and available machine component. They offer many advantages.

- **Freedom from maintenance**Plastic bushings can replace bronze, metal -backed and custom injection-molded bearings in almost any application. Their resistance to dirt, dust and chemicals make plastic bearings a 'fit-and-forget' solution.

- **Cost Savings:** Plastic bushings can reduce costs up to 25%. They feature high were resistance, a low coefficient of friction and can replace more costly alternates in a variety of applications.
- **No Messy Lubricants:** Self-lubricating bushings transfer lubricant onto the shaft to help lower the coefficient of friction and are impervious to dirt, dust or other contaminants.
- **Consistent coefficient of friction (COF):** Plastic bearings are designed to maintain a low COF consistently over the lifetime of the bearing. Compared to metal-backed bearings, which can become scratched and increase the COF, plastic bearings often last longer.
- **Corrosion-and chemical resistance:** Plastic bearings can be used in wash-down applications, salt water and harsh chemicals without compromising performance. Water can even be considered as a lubricant for plastic bearings.

In automotive design, plastics have contributed to a multitude of Innovations in safety, performance and fuel efficiency, but it require never-ending research and improvement. Leading experts say that the easiest and least expensive way to reduce the energy consumption and emissions of a vehicle is to reduce the weight of the vehicle. It is estimated that every 10% reduction in vehicle weight results in 5% to 7%fuel saving. Thus for every kilogram of vehicle weight reduction, there is the potential to reduce carbon dioxide emissions by 20kg. The incorporation of the lightweight materials in automotives is a necessity and our common need.

Design Calculations

1. Bush Inner Diameter (X) is considered as 0.394 +0.00/-0.01 inches
2. Bush Outer Diameter (Y) is considered as 0.787+0.01/-0.00 inches
3. Bush Thickness/Length (L) is considered as 0.394 inches
4. Unit Loading is calculated by using the formula
   P=F/DL
   Where, P-Bushing pressure (Psi)
   F-Total load on the bearing Lbs which is equal to 22 Lbs
   D-Bushing inner diameter in inches
   L-Length of the bush in inches
   After applying the values on the formula, P=22/(0.394/0.394)=22 Lbs
5. Running velocity for reciprocating applications
   V=(LS*C*2)/12
   Where V-Running velocity in ft/min
   LS-Length of the stroke in inches assumed to be 1.97 inches
   Now we can get V=(1.97*20*2)/12=6.57 ft/min
6. Coefficient of friction can be calculated by using the following formula
   m=FFR/2FN
   Where FFR-Measured Friction force with the help of transducer (N)
   FN-Normal Force acting on the shaft (N)
   M-Coefficient of friction

Litrature Review

Rodriguez Fereira (Oct 2011) : have investigated **"Friction and wear properties of polyamides filled with molybdenum disulphide (MoS2)",** The results presented here PA 66 sliding against steel is sensitive to stick-lip motion and favourable behavior in friction and wear was observed in the PA66 with Molybdenum disulphide additives. The highest friction coefficient and wear level was encountered with PA6 without any additives. The molybdenum disulphide additives influence the material to have high wear resistance and low co-efficient of friction. The experimental results demonstrates that the friction coefficient of PA6 increase with increasing the temperature caused by frictional heating. PA66 composite filled with molybdenum disulphide (MoS2) has lower coefficient of friction on comparing with PA6 due to the addition of nanoparticles.

Igus@(Feb2013): published an article of **"Why perform plastic bearings outperform metal",** The discussions published here 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. 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. 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. 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 plain bearings are available off-the-shelf in many designs, sizes, materials, and even colors to meet wide-ranging performance demands.

Engineers Edge(2016): Published article on "Molybdenum Disulfide Disulfide(MoS2) Coatings Lubrication Review" and the discussions considered here Molybdenum disulfide is often a component of blends and composites where low friction is sought. A variety of oils and greases are used, because they retain their lubricity even in cases of almost complete oil loss, thus finding a use in critical applications such as aircraft engines. When added to plastics, MOS2 forms a composite with improved strength as well as reduced friction Polymers that have been filled with MoS23 include nylon (with the trade name Nylatron), Teflon, and Vespel. Like graphite, MoS2 has a low friction coefficient, but, unlike graphite, it does not rely on adsorbed vapours or moisture. In fact, adsorbed vapors may actually result in a slight, but insignificant, increase in friction. MoS2 also has greater load carrying capacity and its manufacturing quality is better controlled. Thermal stability in non oxidizing environments is acceptable to 1100C (2012° F), but in air it may be reduced to a range of 350 to 400° C (662 to 752 °F). There are currently no clear lubrication alternates to molybdenum disulfide.

S.N. Namazov (May 2012): Published paper **on "Properties and Structural characteristics of powdered sintered materials on the basis of iron"** and results presented here the mechanical and antifriction properties of materials received by pressing without application of technological greasing almost twice exceeds the similar properties of materials received by pressing in usual conditions.

Ing. Katarina Szeteiova (2013): Published article on **"Plastics in Automotive Markets today"** the article gives an overview about the plastic materials currently used in automotive industry. A short history of automotive industry from plastics point of view and exact types of raw materials which replaced the metal components in our cars already with their advantages, also reason for development. The conclusion of this article is providing a summary of development and research the world is working on and the way we're following.

Katie Gerard (Jul 2013): published article o **"6 Reasons why plastic bearings are perform better than metal"** and discussions posted here is that lots of engineers are coming around to the versatility, economy, and cleanliness of plastic bearings. There are many low-cost materials available for a variety of applications, such as Nylon, Teflon, Polyethylene, and PEEK. Plastic bearings are generally made of a thermoplastic alloy with a fiber matrix and solid lubricants, accounting for their superior strength and consistently low coefficient of friction. Take a look at this list to find out more reasons to make the switch to plastic bearings.

Dr.Mac(Dec 2015): Published article on **"4 Reasons Molded plastic is replacing powdered metal in bushings and thrust washers"** the article outlines that Engineers are turning to molded plastic bushing and bearings as a replacement for powdered and sintered metal wear components. As a replacement for powdered metal bushings and thrust washers, molded plastic has proven to be more cost effective and more reliable, as downtime for repairs and replacement of bushings is reduced. The result is equipment that is safer and more environmentally friendly because of the reliability of plastic wear products.

Regina M Dick (Jul 2015): Published article on **" Polymer bushing taking a beating: Two important concepts behind wear and tear"** the article concluded that Polymers behave very differently from metal when it comes to wear, but are an ideal choice for many bushing applications as long as you understand the concepts behind the wear andtear of polymer bushings. Bushings have two mechanisms of were, adhesion and abrasive. Adhesion occurs when two surfaces come into direct contact and the atoms from one surface adhere to the other surface. Abrasion occurs when a harder surface contacts a softer surface and removed material from the softer surface. For polymer bushings, the primary mode of wear is adhesion. The key to understanding were by adhesion is a proper understanding of how polymers respond to friction.

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