IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 5, May 2022

Applications of Polymer Gears in Different Industrial Applications over Metallic Gears

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ABSTRACT: ***Gears, which are utilized in the majority of machines in the industry, are the most prevalent and crucial components of machine and process transferring systems. Metal gear makes loud sounds, high frictions, and wear in performance, and the gears are more expensive to address these concerns, thus they are currently replaced with polymer gears or plastic gears. Because of its many qualities such as cheap cost, self-lubrication, and wear and tear resistance, with large production, composite polymer gearing has a broad technology sector. The study is based on the configurations of polymer and non-polymer gears, such as metallic gears with loading as well as the velocity of an engine in the testing equipment. The testing results in an analysis of several elements of all the tested gears such as their characteristics, efficiency, and performance, resulting in the conclusion that cast iron gears will soon be replaced with polymer gears due to their qualities and workability with electric or home machines.***

KEYWORDS: ***Carbon Fiber Reinforced Polymer (CFRP), Gear, Machines, Power-Transmission, Speed.***

1. INTRODUCTION

Gears are most critical component of every machine or system's power transfer mechanism. Distinct gears have different roles and importance in their appearance, and they have a wide range of industrial uses. However, polymeric gears are currently widely employed in a variety of applications due to various advantages such as lightweight, superior damping resilience, self-lubrication, and low cost. Polymer gears are increasingly being used owing to their unique properties, and they are rapidly displacing metal gears. Polymer gears were formerly employed mostly in tiny electrical equipment such as electric toys, but now they are used in low, medium, and high - power density transmission systems inside the vehicle industry. Depending on their form, various kinds of gears have varied industrial applications [1]–[3].

Metallic gears are constructed from basic metals such as steel as well as cast iron. Cast iron is tougher than steel and has a higher melting and boiling point. Metal gears are developed for high-power generating systems with high friction. The high heat generated by the high power generating system causes a rise in the temperature and pressures within the operating system. When constructing any form of gear for just any industrial use, heat is the most critical issue to consider. It is vital to understand the application area where the gear will be employed. Metallic gears have several industrial applications. The gear system's primary role is to transmit power inside the system. Because metal gears are hard, the power required to wear them is more, making them handy and utilized in industry [4].

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The polymer gears are composed of carbon reinforced fiber polymer (CRFP) with a distinct materialistic element makeup. Many machines employ polymer material gears because they are less expensive, have better damping tolerance, and are lighter than metal gears. Polymer gears are used in applications ranging from low-power transmission to moderate and high-power transfer in the automotive and automation industries as shown in Figure 1. There are now several polymer gear design guidelines that have been produced by altering the conventional metal gear design approach. As technology advances, new materials with enhanced functions and qualities are brought into the market. Metal gears are heavy, which results in a high starting cost because the base element utilised to manufacture the gear is iron. Polymers are the CRFP, which is employed in the production of low-cost polymer gears. The application and fabrication of these types of gears varies because the base components employed have distinct physical and chemical characteristics [4]–[6].

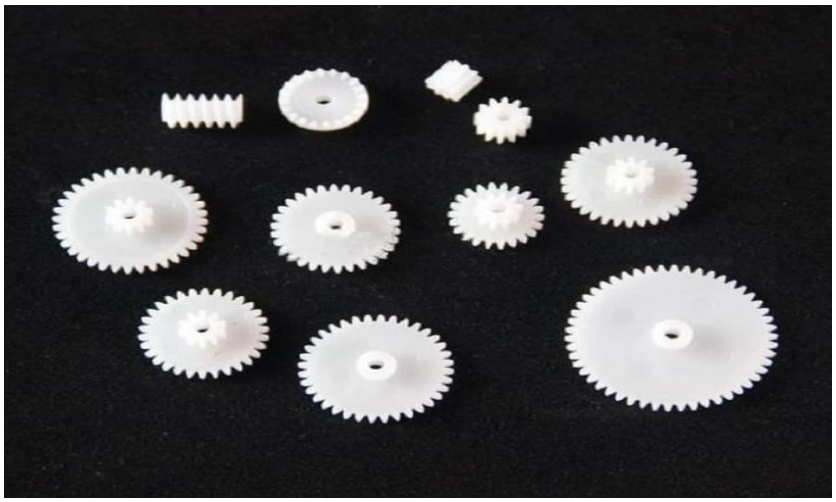

Figure 1: Illustrates the Different Types of Polymer Gears Used in the Industries for Various Application [Source- robu.in].

It will take a little extra consideration and a deviation from the norm to design polymer gears. To accommodate bending stresses, tooth shapes and total height may have to be altered. Modifications to the standard contact pressure at the tooth's root may be necessary. The polymer's flex strength will undoubtedly be important, therefore output and input torque needs will have to be carefully examined. While polymer gears have many benefits, it is important to remember that they vary fundamentally from steel gears. The selection of materials and adherence to customization necessary to fulfil the physical, thermal, and wear demands of the equipment must all be carefully considered [7]–[9].

The study compares the numerous types of gear available on the market with varied compositions according to their physical and chemical qualities, as well as their field of use. Gear design is a well-known procedure for metal gears, however polymer gear design is still in its early stages. The research compares the performances, efficiency, and workability of gear for certain tasks with different compounds or compositions. The study is based on data gathered when executing various

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 5, May 2022

operations on the gears for various compositions. The findings and conclusions are explored further at the end of the study [10]–[13].

Acetal and nylon are the two polymers that are utilised the most often in the construction of gears. Nevertheless, there are several variants even among this category. Using brand names like Delrin, Duracon, and Celcon, several acetals are created. Each of these brand names uses distinct formulas to alter the mechanical qualities of the product. They may increase tensile strength, provide lubrication, or render the material appropriate for contact with food. The same is true for nylon, which has several different trade names including MC901, MC602ST, Nylaton GSM, and many more. While type 12 nylon has also been reported being used, type six nylon is the most common variety utilised for gearing. The number of methyl ethylene (CH2) atoms on either side of the nitrogen atom in the polyamide chain determines the classification of nylon kind. The fact that Nylon 12 includes 12 methyl ethylene molecules on every side further suggests that it has crystallised to a greater extent. Note that crystallisation prevents water from absorbing, hence Nylon 12 will tolerate humidity greater than Nylon 6.

According to observations, several studies emphasizes the physical and chemical features, operating efficiency, and designs of polymer and non-polymer gears. Most study suggests that polymer gears will soon replace metal gears in gearboxes owing to their properties, however there has been little significant research on comparative evaluations to identify which materials in the market is recommended for constructing the gears depending on their area of use. The study focused on the many varieties of polymer as well as non-polymer gears, with the polymers gears applications rising as material qualities improve.

2. DISCUSSION

The forage production machine is used for study because it is a normal function in comparison to industrial machines, but it works under different conditions on a daily basis. The machine is analyzed after a one-year systematic search wherein the machinery are worked on varied load situations, speeds, and gearbox compositions that comprise spur gear composed of different base parts. The devices were tested for a year, with four tests that varied the speed and continuous load for that speed**.**

Cast iron gear produces the most noise since it is more oiled than other two varieties. Cast iron requires constant lubrication to prevent friction and loud sounds. Because of the difference in carbon content, steel gear is more corrosion resistant than cast iron gear. Because the CFRP gear does not require lubrication, the gears do not generate any noise during friction. Because carbon polymers form the foundation ingredient, the plastic gear utilized in the machine does not corrode. The cast-iron gearing is heavier than the other two, while the metal gear is smoother in operation yet produces less noise than the cast-iron gear. The polymer gear utilised makes no noise when functioning since there is no friction, and lubrication is not necessary because the fibres used are self-lubricating.

Features of Plastic Machined Gears:

- Because machined plastic gears are less dense, they are lighter and have less inertia.

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- They require little upkeep.
- Due to the malleable nature of its substance, they can absorb stress and vibration.
- They generate less commotion.
- Their coefficient of fiction is modest.
- They self-lubricate, and even when they run dry, they resist wear.
- They last longer between repairs.
- They are suitable for use in damp and locations where food is prepared.
- They are resistant to corrosion.

In several fields and uses, polymer gears are typical. A polymer gear has benefits such as reduced noise, self-lubricating properties, significant weight reduction, and cost savings. Polymer gear have been employed effectively for many years in anything from drive gearing in copiers to paper mill gears. But polymers throw whatever know regarding metal gear design out the window. When constructing gears out of plastic, a variety of considerations, such as thermal expansion and contraction, physical strength, moisture absorption, and potential chemical exposure, must be taken into account. Cast nylons, nylons used in injection molding, polyester, and acetyl are typical polymers used in gears. The basic polymers are strengthened with a variety of fillers, including glass, carbon fiber, aramid fibers, and other additives that increase lubricity.

Plastic gears have the capacity to carry greater loads because to their teeth bending and load-sharing characteristics. Bending stress may attempt to bend the gear's teeth and tear them away from the main gear material. These pressures result in static stress and fatigue, which ultimately lead to tooth breaking failures. The base of a gear teeth may fail and wear due to contact stress. In other words, polymer gear teeth distribute the weight over a greater number of teeth by deflection more while under pressure. The plastic gears' ability to support more weight is increased by the load sharing capacity.

Plastic gear manufacture is often less costly than metal gear production. Plastic gears are often 50% to 90% less expensive than metal gears since they don't need any further polishing. In comparison to metal, molding plastic allows a wider variety of effective gear shapes. For creating forms like internal gears, worm gears, and cluster gears, where the cost of manufacture in metal might be prohibitive, molding is the best method. High degrees of accuracy may be achieved using plastic gears. Consistent materials required and precise molding process control may accomplish this. Unlike metal gears, plastic gears are not susceptible to corrosion. Because of its relative inertness, they can be employed in water meters and chemical plant management.

Compared to metal gears that are the same size, plastic gears are lower in weight. While steel has a specific gravity of 7.85, nylon and acetyl have closer to 1.4 specific gravities. Metal gears cannot deflect as easily as plastic gears to absorb impact pressures. Localized loads that cause tooth faults and misalignment are likewise distributed by plastic gears. Because of the noise-dampening characteristics of plastics, plastic gears provide for quieter running gear. Due to the need for flexible materials and very precise tooth forms, plastic is a must for quieter drives. Due to their natural lubricity, plastic gears are perfect for presses, toys, and other low stress and dry gearing

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applications. Thus, polymer gears are useful and should be used in the industries due their different efficient properties.

3. CONCLUSION

Cast iron gears have been employed throughout history to develop devices that are still in use today. Steel gears are employed where frictional losses are low. Polymers gears are new to the market because they are new but their use and design. The methods for designing various types of composite materials are improving. Polymer gears are easier to install than other materials gears. Polymer gears are low in weight, which will naturally cut the cost of equipment in the coming time when large machines begin to use polymer gears. Polymers gears are innovative and therefore can substitute cast iron gear, which is expensive and difficult to transport. Steel gears were primarily employed in places where there was a high risk of rusting in place of iron, but because both are metals, there is corroding after a certain life of the gear, so polymer gearboxes are in use, and their application is expanding not only in robotic industry sectors but also in the motor car and electrical fields wherever gears are employed in the machine.

REFERENCES:

[1] C. M. C. G. Fernandes, D. M. P. Rocha, R. C. Martins, L. Magalhães, and J. H. O. Seabra, "Finite element method model to predict bulk and flash temperatures on polymer gears," *Tribol. Int.*, 2018, doi: 10.1016/j.triboint.2017.12.027.

[2] A. K. Singh, Siddhartha, and P. K. Singh, "Polymer spur gears behaviors under different loading conditions: A review," *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology*. 2018. doi: 10.1177/1350650117711595.

[3] K. Mao *et al.*, "The wear and thermal mechanical contact behaviour of machine cut polymer gears," *Wear*, 2015, doi: 10.1016/j.wear.2015.01.084.

[4] A. J. Mertens and S. Senthilvelan, "Durability of polymer gear-paired with steel gear manufactured by wire cut electric discharge machining and hobbing," *Int. J. Precis. Eng. Manuf.*, 2016, doi: 10.1007/s12541-016-0023-y.

[5] J. Tavcar, G. Grkman, and J. Duhovnik, "Accelerated lifetime testing of reinforced polymer gears," *J. Adv. Mech. Des. Syst. Manuf.*, 2018, doi: 10.1299/jamdsm.2018jamdsm0006.

[6] B. Trobentar, S. Glodež, J. Flašker, and B. Zafošnik, "The influence of surface coatings on the tooth tip deflection of polymer gears," *Mater. Tehnol.*, 2016, doi: 10.17222/mit.2015.056.

[7] K. D. Dearn, T. J. Hoskins, L. Andrei, and D. Walton, "Lubrication regimes in high-performance polymer spur gears," *Adv. Tribol.*, 2013, doi: 10.1155/2013/987251.

[8] B. Trobentar, S. Glodež, B. Z. Prometheus, and B. Zafošnik, "Deflection Analysis of Spur Polymer Gear Teeth," *J. Multidiscip. Eng. Sci. Technol.*, 2015.

[9] M. Kalin and A. Kupec, "The dominant effect of temperature on the fatigue behaviour of polymer gears," *Wear*, 2017, doi: 10.1016/j.wear.2017.02.003.

[10] S. Platias, K. I. Vatalis, and G. Charalampides, "Suitability of Quartz Sands for Different Industrial Applications," *Procedia Econ. Financ.*, 2014, doi: 10.1016/s2212-5671(14)00738-2.

[11] R. Joshi and A. Kuila, "Lipase and their different industrial applications: A review," *Brazilian J. Biol. Sci.*, 2018, doi: 10.21472/bjbs.051004.

[12] W. Yang, E. Fortunati, F. Luzi, J. M. Kenny, L. Torre, and D. Puglia, "Lignocellulosic Based Bionanocomposites for Different Industrial Applications," *Curr. Org. Chem.*, 2018, doi: 10.2174/1385272822666180515120948.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 5, May 2022

[13] E. Matei, A. M. Predescu, A. Predescu, E. Vasile, and C. Predescu, "Investigations on nano-iron oxides properties used for different industrial applications," *Optoelectron. Adv. Mater. Rapid Commun.*, 2011.