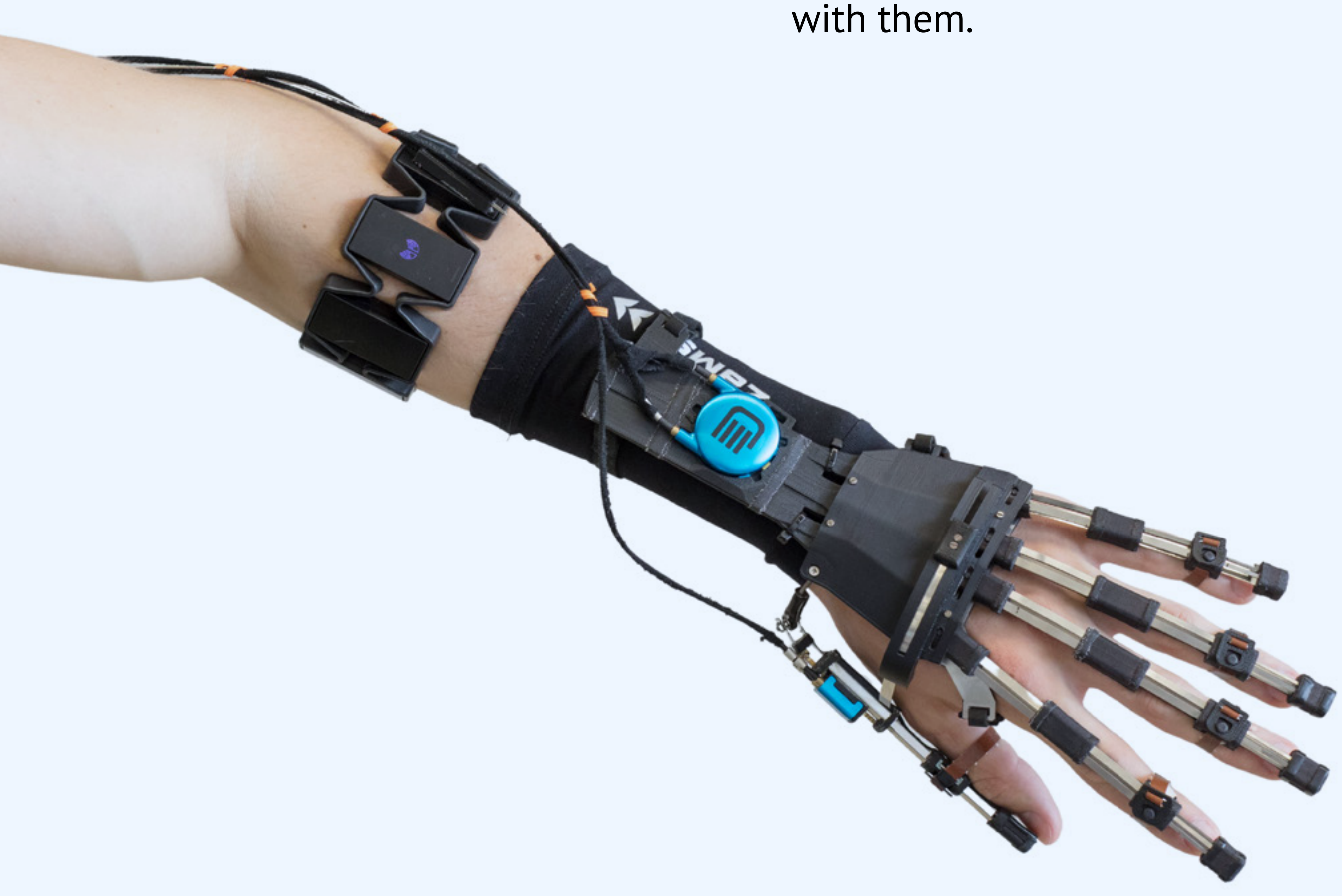
The engineer's guide to 3D Printing with wear-resistant plastic materials.

A comprehensive introduction to 3D printing with wear-resistant plastics, exploring their origin, benefits, and the technologies available to print with them.



Introduction

In the ever-evolving landscape of engineering and manufacturing, 3D printing has emerged as a technology, promising to solve a myriad of challenges. However, not all 3D printing materials are created equal. This comprehensive guide aims to shed light on a specialized category of 3D printing materials—wear-resistant plastics.

These unique materials are not just another addition to the growing list of filaments, powders, and resins available in the market. They are engineered with a specific purpose: to excel in low-friction sliding applications. Unlike generic materials that offer broadly desirable attributes like tensile strength or flexibility, wear-resistant plastics are designed to meet a highly specific engineering need. Infused with solid lubricant additives, these materials offer unparalleled wear resistance and sliding performance, setting them apart in the additive manufacturing materials market.

The guide serves as a comprehensive introduction to 3D printing with these wear-resistant plastics, exploring their origin, benefits, and the various technologies available for printing them. Whether you are an engineer looking for innovative solutions in prototyping and production or an industry professional seeking to understand the latest advancements in material science, this guide offers valuable insights.

In the pages that follow, we will delve into the specifics of why these materials exist, how they can be exploited for maximum advantage, and the different technologies available for printing them. From the basics to advanced applications, this guide aims to equip you with the knowledge you need to make informed decisions in the realm of 3D printing with wear-resistant plastics.

Chapter I: Introduction to 3D Printing with Wear-Resistent Plastics

3D printing materials from igus are the only filaments, powders, and resins developed specifically for low-friction sliding applications. Here we discuss the basics and benefits of these unique materials.

3D printing has long promised to solve a variety of engineering challenges. With its low startup costs, short lead times, and high level of geometrical freedom, additive manufacturing can help engineers find new and innovative solutions in prototyping and production.

Materials play a big role in the identification and execution of these solutions. However, few 3D printing materials are developed to fill a highly specific engineering need. Instead, most materials are designed to suit a range of applications and industries, promising broadly desirable attributes like tensile strength, printability, or flexibility. The few specialty materials on the market include products like ESD-safe powders and flame-retardant filament.

Cologne-based plastics specialist igus is one company making 3D printing materials that solve a genuine engineering challenge. The bearings expert has developed a range of 3D printing filaments, powders, and resins with unique tribological properties. Solid lubricant additives make these materials exceptionally wear-resistant, giving them sliding performance unlike anything else on the additive manufacturing materials market.

This article serves as an introduction to 3D printing with wear-resistant plastics for motion and sliding applications, looking at why these products exist, how they can be exploited for maximum advantage, and the different technologies available for printing them.

Why use wear-resistant 3D printing materials?

In the not-too-distant past, 3D printing was considered first and foremost a prototyping technology. In some contexts, the term "rapid prototyping" was synonymous with 3D printing, with a focus on the speed and low cost-per-unit of the technology in small quantities. Today, additive manufacturing has reached a level of maturity where it is also considered a viable tool for production of end-use parts. This opens up many possibilities for engineers.

Several 3D printing materials are suitable for end-use parts. High-performance filaments like PEEK offer exceptional strength, while titanium alloy powders for powder bed fusion have been deployed in aerospace applications. However, in the area of moving parts like bearings, sliders, and rollers, only igus 3D printing materials have the wear resistance and low level of friction that can guarantee high performance over a long period of time. So, if an engineer requires both excellent sliding performance coupled with the inherent advantages of 3D printing — geometrical freedom, short lead times, one-off parts, and more — they require igus tribo-materials.

Before the development of igus 3D printing materials, the best options for sliding applications were nylons such as PA6 and PA66. However, the utility of these materials is limited by two factors. First, nylons have a higher coefficient of wear than genuine tribo-materials, giving them a relatively short service life. Second, they have substandard printability due to their hygroscopic nature: highly susceptible to humidity, they can produce printing defects if not fully dried before use. A better plastic for sliding applications is POM, but this material is almost impossible to print and is better suited to CNC machining, in which it does not need to be melted.

The key benefits of 3D printable tribo-materials

The benefits of 3D printable tribo-materials can be divided into two categories. First and foremost, there are the unique **performance** advantages of these specialist materials, such as the long service life for motion parts like bearings. Secondly, there are several important process **advantages** relating to the behavior of the material during the 3D printing process.

Performance advantages of igus 3D printable tribo-materials include:

- **Low coefficient of wear:** igus materials exhibit up to 50x greater wear resistance than standard materials like ABS or nylon.
- **Long service life:** due to the exceptional wear resistance of the materials, parts have a long service life
- **Performance comparable to molding materials:** igus 3D printing materials are suitable for end-use parts or prototypes, offering similar performance to molding materials
- **Range of materials:** broad range of tribo-materials for different applications, such as iglidur i3 for the best price-performance ratio for tribo-parts, igumid P190 for structural components, iglidur i150 for easy processing, iglidur i8-ESD for sliding parts with anti-static properties, and many more.

Process advantages of igus 3D printable tribo-materials include:

- **High machine compatibility:** open materials suitable for most 3D printing hardware; many materials even compatible with low-cost machines
- **Printability comparable to standard materials:** unlike many high-performance plastics, many igus tribo-materials require standard printing parameters with moderate temperatures
- **Resistance to water absorption:** unlike nylon, most igus materials are not hygroscopic, making them resistant to water absorption and unlikely to produce defects even in humid ambient conditions (iglidur A350, as a high-temperature filament, requires actice drying)

Choosing the right technology and material

3D printing tribo-materials from igus come in three formats for different additive technologies: filaments for fused filament fabrication (FFF), powders for selective laser sintering (SLS), and resins for digital light processing (DLP) and liquid crystal display (LCD). These technologies have their respective advantages and disadvantages when it comes to sliding applications. Depending on the application specifics, budget constraints, and availability of printing hardware, the most efficient solution may be an in-house print or a customized print order from the igus 3D printing service.

tribofilaments

igus tribofilaments provide the widest range of end-use applications to the widest range of users, as many igus filaments can be processed on standard FFF machines that cost significantly less than other types of additive manufacturing hardware. tribofilaments also represent the largest material category in the igus 3D printing product portfolio, numbering 10 unique formulations suitable for a range of applications.

- For maximum compatibility with low-cost, open-frame 3D printing hardware and standard brass nozzles: iglidur i150 and iglidur i151
- For medium temperature resistance (100 °C) and high dynamic applications: iglidur i180
- For rigorous temperature resistance (170 °C) and flame retardancy: iglidur RW370
- For structural components requiring maximum strength: igumid P150 and igumid P190

Powders

Tribological powders from igus are designed for use on SLS hardware. This technology offers advantages over FFF such as greater design freedom, no support structures, and near-isotropy, with no weakness along the Z-axis. As a result, hardware is more expensive and is typically operated only in industrial environments. Users of SLS hardware can choose between several igus tribological powders to suit their chosen application.

- For good balance of wear resistance, strength, and processability: iglidur i3
- For reliable prevention of electrostatic discharge (ESD) and compatibility with widest range of SLS hardware: iglidur i8-ESD and iglidur i9-ESD
- For abrasion resistance and ideal for worm gears: iglidur i6 and iglidur i6-BLUE

Resins

Tribological resins from igus can be used on standard DLP 3D printers, which can be purchased at costs almost comparable to FFF. Resin 3D printing can produce exceptionally smooth surface finishes and a very high level of detail — ideal for fine-tooth gears. Furthermore, unlike many standard resins, igus DLP materials provide a high degree of strength and stiffness. Compatible with the majority of DLP and LCD 3D printing hardware, igus' iglidur i3000 resin is the first to provide wear resistance up to 60x greater than standard 3D printing resins.

Customers can try the igus 3D printing service for rapid fabrication and shipment of wear-resistant parts or shop the range of igus 3D printing materials for in-house printing.

Chapter II: How High-Performace Thermoplastics are Powering the Future of Therapeutic Applications

Exploring the Role of High-Performance Thermoplastics in Medical Applications, Focusing on RELab Tenoex and Key Properties such as Friction Reduction and Material Resistance

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High-Performance Thermoplastics

3D printing allows creating and producing complex object geometries from a variety of materials. It has significantly reduced the design-manufacturing cycle, production cost, and material waste. This can be attributed to the fact that 3D printing relies on digital CAD data, which allows for multiple iterations of a product to be produced faster and cheaper than the traditional manufacturing methods. Furthermore, the precise layer-by-layer fabrication process of 3D printing eliminates the need for sculpting the final product and generates minimal residual materials.[1]

As technology advances, the variety of materials used in 3D printing has also increased. However, one of the challenges in 3D printing is the need for advanced materials that can match performance and high fabrication standards.[2]

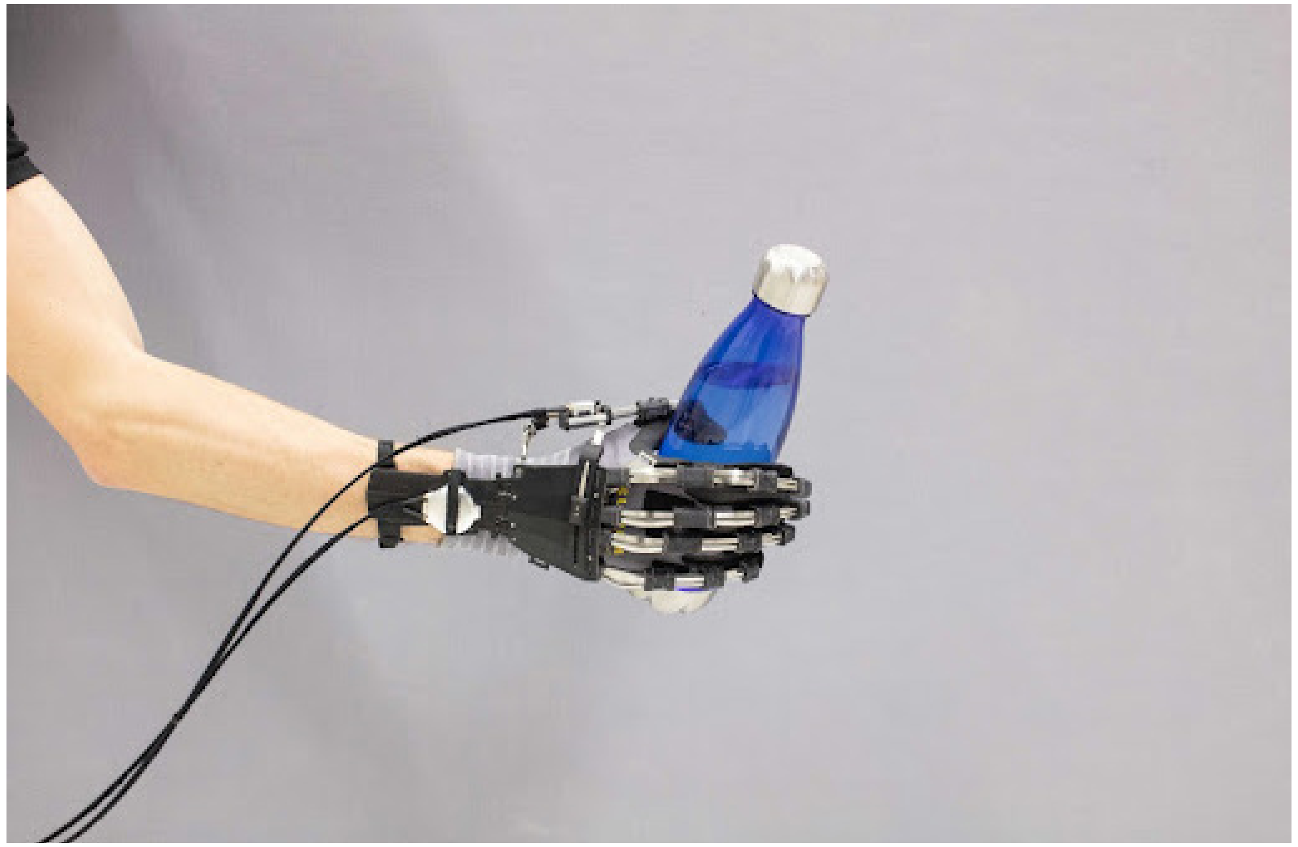
Thus, the sector has been focused on developing new high-performance materials that can improve the efficiency and speed of 3D printing and extend its properties and applications. One example is high-performance thermoplastic polymer. It is suitable for 3D printing techniques and supports the production of pieces with high strength-to-weight ratios and properties that can withstand high loads or harsh environments.[3]

Medical Applications

In medical applications there are high performance plastics such as PEI, PEEK and PEKK in use. These are base materials, not optimized for wear and friction. Printable High-performance-thermoplastics including solid lubricants are for example igus' iglidur A350 and iglidur RW370. These can be processed on high temperature FFF printers.

The remarkable chemical stability and resistance of high-performance thermoplastic polymers make them well-suited for medical parts, capable of withstanding autoclave and chemical sterilization processes. Professor Jumpei Arata of Kyushu University in Japan has developed a hand exoskeleton, the RELab tenoexo, using high-performance igus polymers. The exoskeleton is a fully wearable robotic hand orthosis, designed to assist people with sensorimotor hand impairment. Stroke, spinal cord injury, and cerebral palsy are examples of diseases leading to persistent hand impairment.[7]

The RELab tenoexo is made up of three components: The exoskeleton comprises a hand module, a wristband sensor, and a backpack. Its design allows for a wide range of daily hand activities and therapy tasks, covering approximately 80% of all grasping activities. It has a maximum fingertip force of 6 N per finger, which makes it capable of easily grasping and lifting many everyday objects, including a half-liter water bottle.[8]



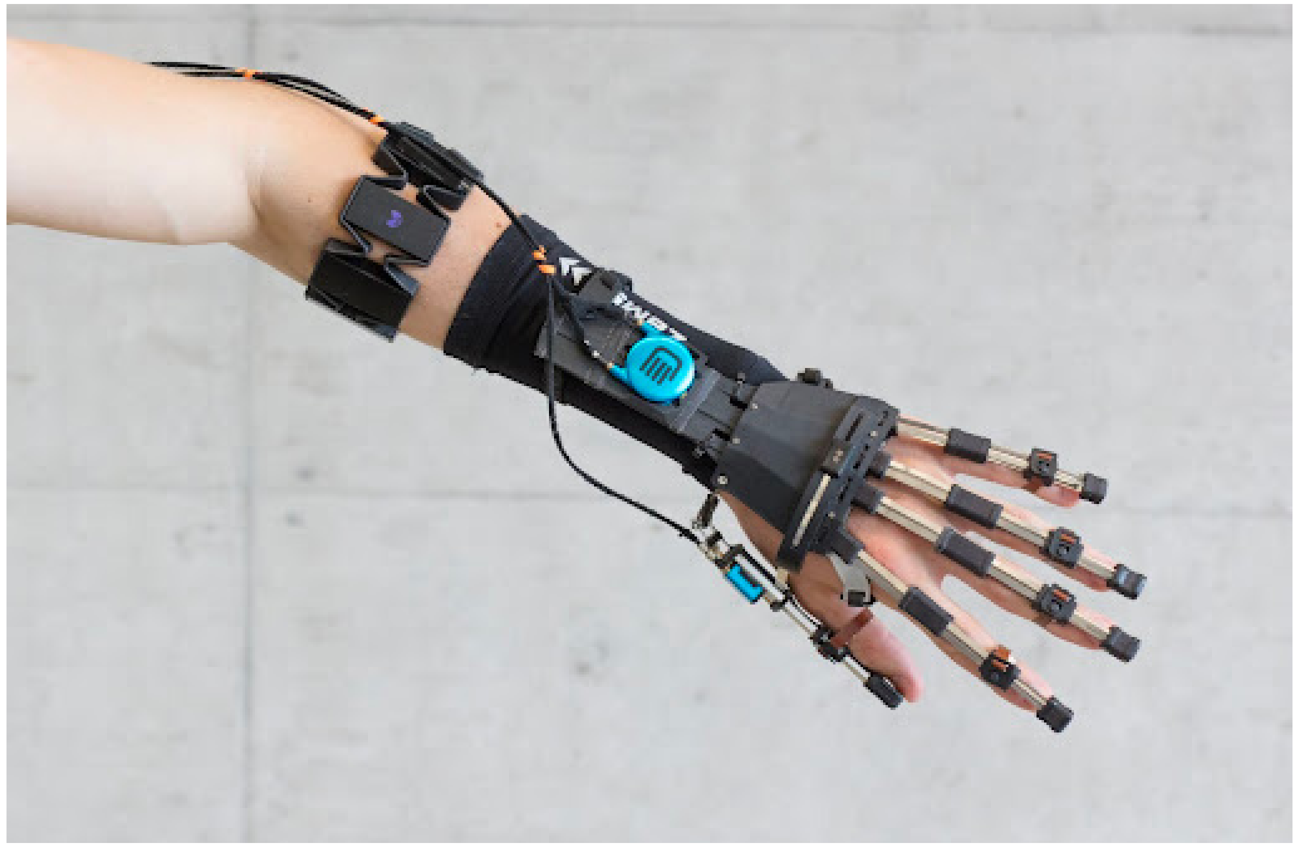
ReLab's tenoex is lightweight and compact, allowing for ease of use.
Image credit: igus

How does the RELab tenoex work?

The patient wears a wristband and backpack while the hand module is attached to their hand using leather straps. The exoskeleton is portable and compact, able to be used during everyday life. The hand module weighs 148g, and the backpack 720g, ensuring patient comfort.

The hand module comprises three thin leaf springs made of stainless steel that are placed on top of each other and connected by four plastic links. It provides power, precision, and lateral grasp.

Additionally, a Bowden-cable-based force transmission system is attached to the middle spring. When moving forwards, the fingers close, and the hand opens when pulled back.



The ReLab tenoex hand exoskeleton actively supports the flexion and extension of the combined index, middle, ring, little finger, and thumb.
Image credit: igus

The device must be lightweight as well as robust: Image credit: igus

When the patient moves the hand, the wristband transmits electromyographic (EMG) signals to a microcomputer located in a backpack. If the patient intends to make a grasping movement, the computer detects this and activates the DC motors, allowing motion. The robotic hand orthosis also has an application that allows users to change the force range and closing speed, select between two grasp types, and configure the control system/intention detection strategies.

However, the prototype faced several issues, such as the delicate finger joint structure. These elements keep the leaf springs together and have a lattice-locking mechanism. The first exoskeleton version used a 3D printer with an ABS filament. The manufacturing method and the material were unsuitable for the manufacture of finger joints due to the high friction, resulting in energy loss when the fingers moved. Furthermore, the resolution of a regular 3D printer was not precise enough to recreate the detailed structure of the finger phalanxes. Here comes the application of high-performance thermoplastics for medical purposes. ETHZ University (Eidgenössische Technische Hochschule Zurich) eventually found a solution.

With the help of selective laser sintering (SLS) technology and the iglidur i6 high-performance thermoplastic from igus, researchers were able to avoid problems with high friction and low resolution, thanks to the igus [3D printing service](#).[9]

Properties of iglidur i6

The iglidur i6 high-performance thermoplastic for laser sintering has proven to have an extraordinary greater wear resistance and much lower friction than conventional materials, ensuring longer service life for parts. With abrasion resistance 50 times higher than standard 3D printing materials, it's well-suited for moving applications like the RELab tenoexo. Moreover, the SLS process eliminates the need for tooling, making it suitable for manufacturing special and delicate parts. SLS uses a selective laser that fuses the powder material layer by layer, ensuring some advantages. For instance, unlike FDM printing, there is no need for support structures because the surrounding powder acts as a natural support, avoiding the need for post-processing.

Moreover, it guarantees uniform distribution of material and good interlayer bonding, which leads to consistent mechanical properties. The unique material properties of iglidur i6 also make it ideal for creating 3D-printed finger phalanxes in an exoskeleton.[10]

Reducing friction

The self-lubricating SLS material iglidur i6 had been specially developed for manufacturing parts subject to friction and was used successfully for manufacturing the finger joints. 3D printed finger phalanges made of high-performance iglidur i6 polymer ensure optimum force transmission. This material is ideal for moving applications and contains solid lubricants, making it easy to handle without needing additional lubrication. This feature makes it suitable for therapeutic applications.

Delicate Parts

Laser sintering as a manufacturing method is ideally suited for replicating complex geometries, filigree structures, and delicate details. This makes it possible to manufacture small volumes and one-off components cost-effectively. iglidur i6 was initialy-ly developed to manufacture worm wheels for robot joints and wear parts in general.

Resistance

One of the most outstanding features of iglidur i6 is its resilience and abrasion resistance. A sintered gear made of this abrasion-resistant iglidur plastic was tested under the same conditions as a machined gear made of POM for two months. The gear made of POM exhibited signs of severe wear after 321,000 cycles and failed after 621,000 cycles. In contrast, the gear made of iglidur i6 continued to function after 1 million cycles, with only minor signs of wear.

Light

The iglidur i6 is an impressively lightweight material, making it ideal for applications where weight is a key factor. For instance, it is a perfect choice for a hand orthosis that needs to be worn for long periods. It is worth noting that the hand module, which features finger joints made of iglidur i6, only weighs 148g.

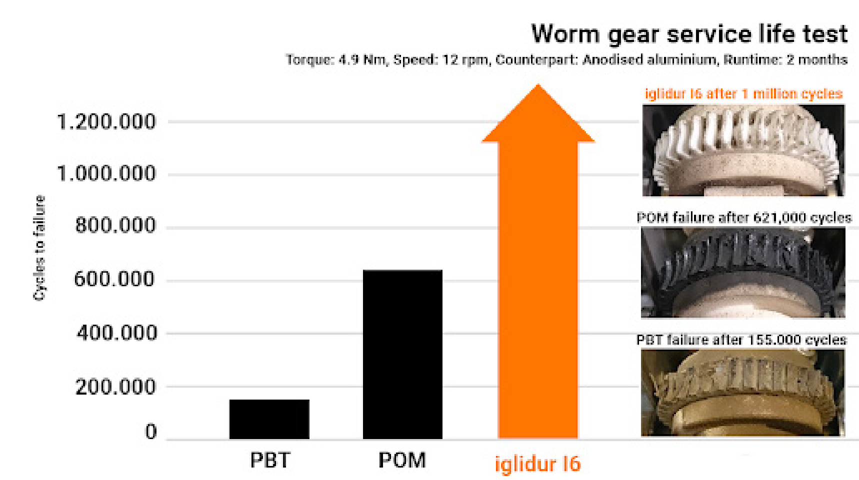


Image credit: igus

The Relab tenoex allows users to change the force range and closing speed, select between two grasp types, and configure the control system/intention detection strategies. Image credit: RELAB ETHZ

There are more current benefits of the application of high-performance thermoplastics. With the help of SLS technology and iglidur i6 high-performance plastic, it is now possible to produce delicate structures of finger joints without the need for support structures. This also eliminates the need for post-processing. For example, pieces from FDM 3D prints tend to have a slightly rough surface, suggesting the need to smooth out the imperfections through sanding.[11] Moreover, RELab tenoexo exoskeletons are individually adapted to fit individual patients. The company developed an algorithm that adjusted the digital model of the exoskeleton to the size of the patient's hand with just a few clicks, thereby avoiding any mistakes. This means the exoskeleton can be manufactured to meet individual customer requirements quickly and without complications.

In addition, with the help of an online 3D printing service tool, ETHZ scientists can order the required parts in just a few minutes. The manufacturing process is usually completed overnight, and the finished finger joints can be fitted after just a few days. This is the only manufacturing method that approaches the speed and cost-effectiveness of 3D printing where a customized small-volume manufacturer is concerned. The adaptable and fast production characteristics of this method are game changers, especially considering that conventional customization methods are complex due to molding or other tool-based methods.

Conclusion

High-performance thermoplastics processed by SLS have exceptional properties, such as being friction-free, allowing for detailed and precise printing, being self-lubricating, lightweight, and being easy to produce. These advantages can lead to a faster and more comfortable recovery for patients when utilized in medical applications.

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Chapter III: 3D Printing an Award-Winning Steering Wheel Aid with Wear-Resistant SLS Powder

igus partnered with German company KEMPF to redesign and manufacture an innovative new driving aid. The award-winning product overcame design and functionality limitations through a combination of advanced 3D design and igus wear-resistant and low-friction iglidur i3 powder for selective laser sintering.

Since its founding in the 1950s, German company KEMPF has helped over a hundred thousand people with limited leg mobility to drive by retrofitting vehicles with its driving aids. Among the company's most game-changing products is the Darios accelerator ring, which enables drivers to control an automatic vehicle's acceleration with their hands using a subtle steering wheel attachment.

Understandably, the innovative driving aid has changed a lot since it was first invented by KEMPF founder Hans Kempf over half a century ago. The KEMPF team has been continually updating the device's design and production to reflect automotive design changes and technological advances.

The most recent iteration of the accelerator ring, the Darios 211, was designed to fit the increasingly popular flat steering wheel design. Flat steering wheels are characterized by a "D" shape and are inspired by racing cars. Understandably, the KEMPF team wanted to make an accelerator ring that would match the shape of these new steering wheels for both aesthetic and function.

However, the redesign process for the flat accelerator ring introduced an obvious challenge for KEMPF engineers: how to retain the device's freely rotating sleeve despite the ring no longer being perfectly round. In the end, a solution was reached thanks to the use of SLS 3D printing and igus specialized 3D printing materials, making Darios 211 the first flat accelerator ring in the world.

Reinventing the wheel

Faced with the challenge of designing a new accelerator ring with a flat bottom, the KEMPF team turned to the 3D printing experts at igus, whose slide-optimized 3D printing materials and 3D design knowledge helped facilitate a solution.

The final ring design comprises over 200 3D printed elements that are flexibly joined together to form a sliding ring over the device's metal core. These elements, printed using SLS technology, are made from iglidur i3, an abrasion- and wear-resistant powder engineered specifically for sliding applications.

3D printing proved to be the right manufacturing technology to create the innovative driving aid for a number of reasons. For one, the design of the ring included a fairly complex geometry made up of several undercuts, which would have been near impossible to achieve using conventional injection molding (not to mention too expensive). 3D printing also allowed for the direct production of the accelerator ring slider, eliminating steps in the production process, such as tooling, which inevitably add time and costs.

Moreover, igus was able to 3D print several hundred sliders in a single build and could deliver parts in as little as 24 hours.

On top of the many benefits SLS 3D printing brought to the table, one of the most important reasons that KEMPF's flat ring slider was a big success was igus' iglidur i3 powder bed fusion material.

The Darios accelerator ring integrates seamlessly within a vehicle's steering wheel, allowing drivers to control the acceleration with their hands. Image credit: Kempf/igus

Spotlighting iglidur i3 powder for SLS

By far the most used material in igus' *3D printing service*, iglidur i3 is a polymer powder engineered specifically for sliding applications. The material's properties are possible thanks to the addition of solid lubricants, which make it suitable for many use cases, like sliders, rollers, racks, spur gears, bevel gears and much more.
The SLS powder also boasts excellent abrasion resistance, performing as much as 30 times better than conventional SLS materials in tribological tests. This is in addition to high wear resistance, strength, and good printability. Like all of igus' 3D printing materials, iglidur i3 is an open material and is compatible with most CO_2 laser sintering machines.

The material's low friction and wear resistance were vital to KEMPF's use case. In comparison to standard 3D printing materials, the iglidur i3 performs twice as well in the rotating friction test, due to the solid lubricants integrated into the material. The primary function of the 3D printed accelerator ring cover is to rotate freely and smoothly over the internal flat ring, which requires a certain degree of lubrication. The sliding-optimized 3D printing material was therefore the perfect choice, ensuring low-friction without requiring any maintenance or additional lubricants.

It's worth pointing out that KEMPF driving aids come with a 30-year guarantee, so every component inside the accelerator ring must be of the highest quality and durability. The 3D printed components of the ring are also permanently installed within the driving aid's sleek leather sleeve, so cannot be regularly maintained. In other words: it has to function perfectly.

Thanks to the combination of iglidur i3's unique material properties and the innovative 3D printed design behind the flat ring accelerator, KEMPF and igus succeeded in creating a product which was recognized with the bronze manus award at Hannover Messe Trade Show in 2019. This award, which igus brought to life more than 20 years ago, celebrates outstanding and innovative sliding applications using igus bearings (injection-moulded or 3D-printed).

iglidur i3 is the most popular material used in igus' 3D printing service, with outstanding abrasion resistance and low friction. Image credit: igus

The sleek Darios 211 accelerator ring seamlessly complements the modern 'D'-shaped design of flat steering wheels. Image credit: Kempf/igus

Accelerated production times and lower costs

In the end, igus' low-friction polymer powder was uniquely qualified to make the first flat accelerator ring a reality. In collaborating with igus and leveraging its 3D printing service, KEMPF not only met the technical requirements for its new Darios 211 product (including flat ring design, sliding capabilities, and durability) but also benefited from faster lead times, cost savings, and production agility.

The 3D printed ring components were produced by igus at its 3D printing facility in Cologne, and igus was able to meet KEMPF's production volume (of over 10,000 units) in under 48 hours. Compared to conventional manufacturing methods like injection molding (which would also have been limited by the complexity of the part's design), 3D printing saved KEMPF time and money by eliminating the need for tooling.

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Chapter IV:
When & How to Use the igus 3D Printing Platform for Wear-Resistant Plastics

The broad range of igus tribo-materials for 3D printing provides solutions for all types of motion parts. The igus 3D printing service allows engineers to order custom printed parts directly from igus.

Wear-resistant 3D printing materials from igus provide engineers with the tools to create high-quality 3D printed motion parts like slides, bearings, gears, and rollers with an exceptionally long service life. These open materials are compatible with most additive manufacturing hardware and have a high level of printability, requiring the same level of expertise as standard 3D printing materials.

Of course, some engineers and manufacturers require high-quality motion parts but do not have access to in-house 3D printing equipment. For such customers, igus offers an online platform for its in-house 3D printing service, through which users can upload a CAD model, choose a material and post-processing options, then order 3D printed parts directly from igus. The on-demand service is ideal for customers requiring prototypes and medium volumes of end-use parts.

This article provides a detailed overview of the igus 3D printing service and its the corresponding iglidur Designer online platform, explaining the key advantages and unique features of the igus platform compared to basic 3D printing service bureaus.

What makes the igus 3D printing platform unique?

The igus 3D printing platform is unique because it combines three tools in one:

1. Pricing for the unique part, material, and quantity

2. Automatic DfM analysis of whether the part can be produced based on its wall thickness and other features

3. Lifetime calculation of the printed part

The lifetime calculation of 3D printed parts is especially notable. Having this feature in an online tool that everyone can use without a login is truly unique. The biggest advantage of this feature is the time it saves the user during testing. Users can pick the best solution for their application, taking into account price, lifetime, and other special requirements.

How is the lifetime calculated?

Developing long-lasting plastics and calculating their lifetime is a key unique selling point for igus, made possible by the company operating a 3,800 m² lab — the largest in the industry — and conducting more than 15,000 tests each year. Test results are added to a large database, logging different wear rates at different speeds, loads, moving types, and many more parameters.

These results are used to make the lifetime for sliding applications calculable. After uploading a CAD model to the online 3D printing platform, the lifetime calculation within the online tool is done in three steps:

1. Click the button „Calculate the service life"

2. Select the sliding surface of your component by mouse click

3. Enter some additional application parameters and click "Calculate"

As a result, the user is shown the expected lifetime in hours for each available material in the overview, so that at the end the user can compare the feasibility, properties, lifetime and price of each material.

Why use a third-party service over in-house 3D printing?

Most engineers understand the benefits of in-house 3D printing. Companies that regularly require one-off plastic prototypes or custom spare parts can often see a quick return on investment on a 3D printer, especially if they have previously used traditional technologies for prototyping. And no third-party service can deliver parts as quickly as in-house production.

So what are the arguments for using third-party 3D printing services instead of buying an in-house printer? Although 3D printing hardware can be a good investment for many companies, there are many reasons why using a professional service can be advantageous.

Order frequency

One of the main reasons why customers use a third-party 3D printing service is that they do not require 3D printed parts at a frequency that justifies investment in hardware. 3D printers require a skilled operator, regular maintenance, and further investment in materials, and this time and cost cannot be justified for infrequent prototypes or very small volumes of parts.

Specialty materials

Demand for specialty materials is another reason why an engineer might turn to a 3D printing service — even if they do have an in-house 3D printer for printing standard materials. Although igus tribo-materials are easy to print, some engineers might need 3D printed motion parts at a frequency that does not justify investment in the raw material.

High-quality hardware

3D printers vary greatly in price. While low-cost FFF hardware can cost under a thousand dollars, SLS systems typically cost hundreds of thousands. Companies that can afford an in-house FFF printer may not be able to afford an SLS system or a high-temperature, industrial-grade FFF printer.

By contrast, 3D printing service bureaus typically operate a large fleet of high-end 3D printers to which customers can gain access without large capital expenses.

Trial, test & transition

Newcomers to 3D printing will often use a 3D printing service before investing in their own hardware. This allows the user to conduct feasibility analysis on the printed parts; if successful, customers may ultimately transition to in-house printing.

Expertise

Another reason why many engineers use a 3D printing service is to exploit the expertise of a seasoned 3D printing professional. By outsourcing production of their 3D printed parts, companies can leverage the experience of the service bureau: the operator will know the best way to handle the material, prepare the build surface, optimize the slicing parameters, and prepare the parts for post-processing.

For this reason, some companies will use an in-house printer for prototyping but outsource high-value parts to a third-party service.

Overview of the igus 3D printing service

As well as providing ready-to-use 3D printing materials in filament, powder, and resin form, igus offers a full-scale 3D printing service, allowing customers to order complex motion parts in low-friction igus materials. No other 3D printing service bureau provides access to igus tribo-materials for motion parts.

To use this service, customers can upload their CAD files (STEP or STP) to the online tool and choose their preferred printing options, and can expect to have their parts shipped within a matter of days. For non-designers, it is also possible to instantly generate standard parts like gears and bearings by inputting dimensions and a few other parameters into the 3D print *CAD configurator tool*. All of these tools can be used free of charge without the creation of a login.

Key benefits

- **Global**: production facilities in Germany, USA, and China
- **Professional**: operations handled by igus 3D printing engineers
- **Unique**: wide choice of igus self-sliding 3D printing materials with up to 50x greater wear resistance than standard materials
- **Lifetime**: Online calculation of the part service life, using the wear results igus has recorded in hundreds of tests
- **Simple**: instant parametric design of standard parts like gears, bearings, and screw nuts via CAD configurator
- **Transparent**: up-front pricing and lead times plus helpful service life calculator for estimating lifespan of printed motion parts

Fast: parts shipped within a matter of days

Model

Users can upload their own STEP or STL files to the online 3D printing service via the simple drag & drop interface.

Alternatively, they can auto-generate custom moving parts for free using the CAD configurator, a simple online parametric design tool provided by igus. Available parts include lead screw nuts, sliding elements, bearings, belt pulleys, rollers, gears, and racks. Users can select the desired part style and dimensions, then export the CAD file in their chosen format.

Material

The igus 3D printing service makes it easy to choose a printing technology and material. Customers unsure of the best iglidur material for their parts can select from a list of requirements and the platform will filter out any unsuitable materials. Additionally, the table of options lets the user quickly compare the delivery time, price, precision, and flexural strength of each material.

When choosing a material, customers can also exploit some helpful features of the 3D printing platform. For instance, users can **calculate the service life** of the proposed part by inputting a few parameters such as the working temperature and minutes of pure movement per hour.

Note that users can also use the 3D printing platform to order injection molded parts made with metal 3D printed tooling. Lead times are longer for molded parts than for directly 3D printed parts, but customers can choose from a wider range of materials.

Post-processing

The iglidur 3D printing platform gives users several post-processing options for their 3D printed parts. These include black dyeing, chemical smoothing, and slide grinding, as well as options for machined holes and machined threads. Users can also request custom post-processing, for which igus will provide a quote once assessed.

Producibility

As soon as the CAD file is uploaded, users can verify that the design is printable. The igus manufacturability analysis tool checks that the design, material, and technology are fully compatible by analyzing features such as wall thickness and available build space.

Customers can try the igus 3D printing service for free, without creating a login, either uploading their unique CAD models or using the CAD configurator for the fast creation of standard parts.

Chapter V: Best Practices for 3D Printing with Wear-Resistant Plastics

To get the most out of igus self-lubricating 3D printing materials, users need to consider material handling, print settings, post-processing, and other factors.

3D printing materials from igus enable the creation of self-sliding motion parts with an exceptionally long service life. Solid lubricants within the plastics lead to excellent wear resistance and low friction, significantly outperforming other thermoplastics like nylon 66.

Most igus low-friction 3D printing materials have a high level of processability. Many filaments, powders, and resins can be used with standard 3D printing hardware and do not require special expertise. However, to get the most out of the materials, a few best practices should be followed, from appropriate material handling to optimized slicer settings.

This article serves as an introductory guide to 3D printing with igus tribo-plastics, discussing pitfalls to avoid and methods for improving the performance of 3D printed parts. The option of outsourcing the printing of parts to the igus 3D printing service is also presented.

Material selection

The igus 3D printing materials portfolio currently consists of 17 products (16 of which can be purchased in the web shop), and users can improve part performance by choosing the right technology and material for the given application. For example, structural parts require a strong material like igumid P150 filament, while worm wheels with fine teeth are highly suited to a material like iglidur i6 powder.

When choosing a 3D printing material, the following factors should be considered:

- Available hardware: igus materials have good processability, but high-performance materials require industrial-grade hardware; for example, iglidur A350 has similar process parameters to PAEK materials and thus requires a high-temperature FFF 3D printer, while igumid P150 is fiber-reinforced and requires a hardened (steel) nozzle
- Ease of use: some igus materials are more challenging to print and require a higher level of printing expertise to achieve optimal results, while others like iglidur i150 are easy to use even for beginners using low-cost equipment
- Application requirements: igus materials offer different levels of performance in terms of strength, stiffness, abrasion resistance, temperature resistance, flame retardancy, electrostatic dissipation, and food safety; required material characteristics should therefore inform material selection

Best practices for tribofilaments

tribofilaments from igus require a few special considerations in order to achieve high-quality FFF 3D printed parts.

Material handling

All igus materials should be stored in a dry place to prevent moisture absorption. Special care must be taken when storing iglidur A350, which is more hygroscopic than other materials and more vulnerable to humidity. Drying the material in an oven or material dryer for four hours or more at 160 °C can prevent printing issues.

Build surface

The bonding agent is the most recommended method for good bonding and furthermore easy removal of parts after printing. The igus bonding agent is recommended for all igus non-high-temp materials: iglidur i150, iglidur i151, iglidur i180, iglidur i190, igumid P150 and igumid P190.

As with all FFF materials, bed leveling should be carried out to ensure good first-layer adhesion and print accuracy.

Print settings

Because igus materials are not standard thermoplastics, users may have to create their own material profiles in their slicing software. The ideal settings vary depending on the chosen tribofilament.

Temperature settings play a key role when printing tribofilaments, and the requirements vary depending on the material. Materials like iglidur i150 and i151 require low nozzle, bed, and chamber temperatures. At the other end of the spectrum, materials like iglidur RW370 and A350 require nozzle temperatures above 340 °C and bed temperatures above 180 °C.

Cooling and fan settings are another important consideration with tribofilaments. To encourage adhesion between layers, it is not recommended to use a fan at all or at least the fan should be adjusted to the minimum necessary setting. This applies to all igus tribofilaments.

When it comes to print speed, the all-rounder filaments like iglidur i150 and i180 can handle fairly fast speeds of around 50 mm/s, while more advanced materials require more caution. For example, iglidur A350 should be limited to 20–30 mm/s, while iglidur J260 should not exceed 20 mm/s.

Nevertheless, there are igus printing profiles available for Ultimaker (Cura), Bambu-Lab, and Prusa.

Post-processing

tribofilaments from igus are suitable for tumbling, as well as other mechanical processes like drilling and milling.

Best practices for powders

For SLS 3D printer users, igus currently offers seven different tribologically optimized powders. These materials can be processed in a similar manner to nylon 12, despite drastically outperforming nylon in terms of coefficient of wear and service life, as well as being more resistant to moisture.

Handling

As with all SLS powders, igus materials require careful handling using personal protective equipment: gloves, a respirator, and safety glasses. Powder should be stored in a cool, dry place, and unsintered powder must be disposed of in accordance with local environmental regulations.

Print settings

All igus 3D printing powders have similar process parameters to nylon 12, although iglidur i8-ESD powder prints best with a process chamber temperature fractionally higher than the other materials.

Post-processing

SLS parts are suitable for a range of post-processing techniques, like chemical smoothing, tumbling, coloring, drilling, and milling.

Best practices for resins

Despite its outstanding strength and sliding performance, iglidur i3000 3D printing resin is easy to print on standard DLP and LCD 3D printers.

Handling

3D printing resins can irritate the skin, so protective nitrile gloves should be worn when handling the material. It should be stored in a dry, cool, and dark place to prevent premature curing. The resin should be stirred in a vat prior to printing.

Print settings

Print settings for iglidur i3000 do not differ greatly from standard resins, though a slightly longer exposure time may be needed. Fine support structures work best, as they can be easily removed.

The igus iglidur i3000 material is suited to highly detailed parts. To achieve the finest detail, users can use a layer thickness as small as 0.05 mm.

Getting the first layer right may require some trial and error. Poor adhesion can be solved with increased exposure time or light intensity for the burn in layer, while over-adhesion can be solved by adjusting the same parameters in the other direction.

Post-processing

Unlike FDM and SLS materials, igus resins are not suited to standard chemical or coloring finishing processes, but they require other post-processing steps specific to vat photopolymerization technologies. Mechanical finishing like milling and drilling is also possible for these parts.

Finished parts should be washed using isopropyl alcohol in cycles of no more than two minutes, with supports removed manually. UV post-curing should be carried out to achieve the desired level of hardness and strength, with more time needed for thick-walled parts, after which parts can be sanded to remove blemishes from support removal.

Outsourcing for igus

Engineers requiring high-quality, low-friction parts can use the igus 3D printing service to order custom parts directly from igus. This may be preferable for customers without their own 3D printing hardware or whose hardware does not meet the criteria for printing high-performance materials like iglidur A350.

Customers can try the igus *3D printing service* for rapid fabrication and shipment of wear-resistant parts or shop the range of igus *3D printing materials* for in-house printing.

Chapter VI: Future Trends in 3D Printing with Wear-Resistant Plastic Materials

Industry leader igus drives innovation and anticipates trends in scalable production, intelligent components, accessibility, and sustainability

Since the early days of 3D printing, the industry has come a long way. Not only have 3D printer hardware and software technologies advanced significantly—with greater precision, faster print speeds, and better consistency—but the range of printable materials has grown enormously—and continues to do so. It's been this expansion of 3D printing materials that has really driven additive manufacturing's adoption across a wider range of industries and for more and more end-use applications.

The German company igus has played an important role in developing new 3D printing plastics, leveraging over 50 years of experience making functional polymer parts to create exceptionally wear-resistant materials. The company has carved out a specific niche for itself in the additive manufacturing market, offering a range of strong, low-friction filaments, powders, and resins engineered for moving and sliding applications.

These materials have already made an array of new applications possible, such as finger joints for an exoskeleton and a special adaptive steering wheel slider, whose design would have been near impossible to realize using conventional methods. The materials' unmatched sliding properties (enabled by special lubricant additives) have allowed igus customers to create low-friction components and assemblies that rival injection molded parts in terms of wear-resistance and function. But this is really just the beginning for igus' 3D printing journey, and for 3D printing in general. The potential and possibilities are endless.

What's on the horizon?

Below are some trends that are taking off in the realm of 3D printing that are particularly relevant for wear-resistant polymers like iglidur and igumid materials for SLS, FFF, and DLP.

Scalable production

One of the biggest trends across the additive manufacturing industry today is the growing viability of 3D printing as an industrial end-use production process. Once a technology used strictly for prototyping (or hobbyist-grade parts), 3D printing is now broadly used across industries like automotive, aerospace, consumer goods, electronics, energy, medical and more, for everything from prototyping, to tooling, to end-use parts.

Material variety is central to this trend, as it offers users a wider range of properties to choose from. For instance, the growing availability of ESD 3D printing materials, such as iglidur i8-ESD and iglidur i9-ESD, are opening up applications in the electronics and semiconductor industries, while tribologically optimized materials can be used to print inherently lubricated parts for various assemblies.

At the same time, a more consistent 3D printing process and the advancement of automated workflows are empowering manufacturers and 3D printing services alike to more easily scale their production. This means 3D printing will become more popular for larger production volumes, such as series production or mass customization.

Intelligent 3D printed parts

An emerging trend with incredible potential across many industries is the creation of intelligent 3D printed components that can gather usage data or alert users when there is a flaw or weakness in their performance. Using conductive 3D printing materials and multi-material 3D printing platforms, sensors can be embedded directly into a 3D printed geometry to impart these special functions.

igus engineers have already developed smart 3D prints, such as an intelligent bearing with sensors that can detect overload and issue predictive maintenance alerts. But the trend doesn't end there: researchers at MIT are currently investigating the ability to 3D print sensors into rotational mechanisms, which will allow the parts to sense their movement.

The benefits of being able to directly print sensors into a part are enormous. If parts can sense their performance over time, users can more easily anticipate when maintenance is required, saving time and costs associated with breakages or system downtimes. It could also open up product innovations. For example, MIT prototyped a smart desk lamp that changes color and brightness based on part rotation.

Greater accessibility

As adoption and demand for wear-resistant, high-performance materials grow, the cost of materials will continue to decrease. This is because the cost for raw consumables will be driven down as production volumes rise (i.e. economies of scale). The lower cost of materials will then in turn further drive adoption of 3D printing and make the technology and high-performance materials more accessible.

The affordability trend is also driven in part by the cost of hardware, particularly engineering-grade machines capable of processing high-temperature and high-performance materials. Today, it is possible to purchase a high-temperature FFF 3D printer with nozzle temperatures up to 500 °C in the range of $25,000, which makes materials like iglidur polymers available for a wider user base.

Ultimately, lower entry costs for adopting 3D printing and the lower cost per part unlocked via cheaper material costs will make additive manufacturing increasingly competitive with more traditional manufacturing techniques, like injection molding, and lower the entry barrier for more users.

Sustainability

Sustainability has become an increasingly important topic within the 3D printing industry, and for good reason. Issues like plastic pollution and carbon emissions are tied to manufacturing and much must be done to curb the industry's impact on the environment.

Across additive manufacturing, sustainability is therefore a leading trend, and many innovative solutions are being explored and implemented.

At igus, the company is aiming to make all its production facilities CO2-neutral by 2025, employing tactics like clean energy sources and recycling programs to cut its ecological impact. The company's self-lubricated polymers, including its range of 3D printing materials, also present a unique opportunity on the sustainability front. Every year, 27 million tons of grease end up in our environment, which leads to problems like water and land contamination.

By turning to igus polymers that don't require external lubrication, it is possible to cut back on grease consumption. Furthermore, due to the materials' high durability, bearings, gears, and other components can have longer functional lives.

Of course, there is more to be done, which is why many polymer 3D printing providers are investing in things like greater process efficiency, material usage efficiency, and material recycling to create a greener future for additive manufacturing.

The future is bright for wear-resistant materials.

As we've seen, wear-resistant 3D printing polymers, such as those developed by igus, offer specific benefits to additive adopters in industries like automotive, industrial goods, and medical. As awareness of these materials grows and as igus continues to develop more materials and support new applications, the potential for high-performance polymers will only rise.

To learn more about igus' 3D printing material range or to place an order for 3D printed parts, get in touch with the team today at: *www.igus.eu/3d-printing-request*.

About igus®

igus® is a globally recognized leader in the manufacturing of innovative motion plastics products for moving applications. With a diverse range of offerings including energy chain systems, cables, lubrication-free polymer bearings, and linear systems, igus® has carved a niche for itself in the industry. The hallmark of their products lies in their cost-effectiveness, durability, and versatility, making them a preferred choice across various industrial landscapes.

Operating with a strong ethos of environmental responsibility, igus® is committed to delivering solutions that are not only efficient but also sustainable. In this context, „Tech up, cost down" is an important guiding principle for the company. igus® always wants to offer its customers solutions that improve the technology in an application and thus make it more durable, while at the same time ideally leading to cost savings on the customer side.

With a robust presence across 31 countries and partnerships extending to over 80 countries worldwide, igus® has truly established itself as a global player. The company's expansive network ensures that it stays close to its customers, understanding their unique needs, and delivering solutions that are tailored to meet those needs.

At the heart of igus®'s success is its unwavering focus on research and development. By continually investing in R&D, the company strives to stay ahead of the curve, ensuring that its products and services evolve to meet the changing demands of the industry. This forward-thinking approach has not only helped igus® build a strong reputation but also a loyal customer base that relies on its expertise to navigate the challenges of the modern industrial world.

About Wevolver

Wevolver is a global platform and community that provides engineers with the knowledge and connections to develop better technology.

We bring a professional audience of engineers informative and inspiring content, such as articles, videos, podcasts, and reports, about state-of-the-art technologies.

The knowledge on Wevolver is published by various sources: universities, tech companies, and individual community members. Next to that, we manage a network of over 50 technical writers who create content for our customers and publish that on Wevolver.com

Millions of engineers leverage Wevolver to stay up to date, find knowledge when they are developing products, and leverage the platform to make meaningful connections.

Wevolver has won the SXSW Innovation Award, the Accenture Innovation Award, and the Top Most Innovative Web Platforms by Fast Company. Wevolver is how today's engineers stay cutting edge.

This report was written collaboratively by Benedict O'Neill and Tess Boissonneault and edited by Wevovler and Igus staff.