DESIGN GUIDE

ERGONOMIC GRIP DESIGN CONSIDERATIONS

How to Improve Human Interactions with Handheld Devices

AVIENT™

Today's consumers seek products that offer a sophisticated experience. Creating such products requires many deliberate and informed design choices. These decisions affect not only each person's experience with the product and ability to use it effectively, but also its manufacturability and durability.

This design guide looks at design considerations and choices affecting the ergonomics of handheld devices – specifically, their grips – and explains how these factors contribute to higher performance, improved ease of use and production efficiency. Here you'll find guidance on human factor design principles, material selection, regulatory requirements, engineering tools and the manufacturability of materials that can help you create standout products. We'll even discuss the emotional and psychological aspects of design and suggest ways to improve sustainability.

TABLE OF CONTENTS

DESIGN STRATEGIES TO IMPROVE USABILITY

The importance of ergonomic grip design can't be overstated. It not only adds to the user's comfort but also can enhance efficiency and safety, whether at home or at work. Ergonomic grips in handheld devices are essential to minimize forceful exertion, repetitive motion, contact stress and vibration that can produce discomfort, fatigue and even injury.

Maximizing the usability of a handheld device involves defining the use case, the user, the anthropometric data (body measurements), the grip architecture and then validating the design.

DEFINING THE USE CASE

No single grip design is perfect for every product. To determine which design will optimize the usability of a handheld device, you first need to understand the **use case** for the specific product.

One of the first steps is to observe and document the step-by-step use of the product by conducting a thorough **task analysis**. This process can be mapped in various ways. Figure 1 illustrates a storyboard method to capture the key task analysis steps of a diabetic insulin routine. Video recording is another great way to document the tasks.

IT'S IMPORTANT TO CAPTURE THE FOLLOWING:

Initial storage

- How and where is it stored?
- What is it stored with?

Setup for use

- How is the product prepped for use?
- What other products are used with it?
  - How are they arranged in relation to each other?

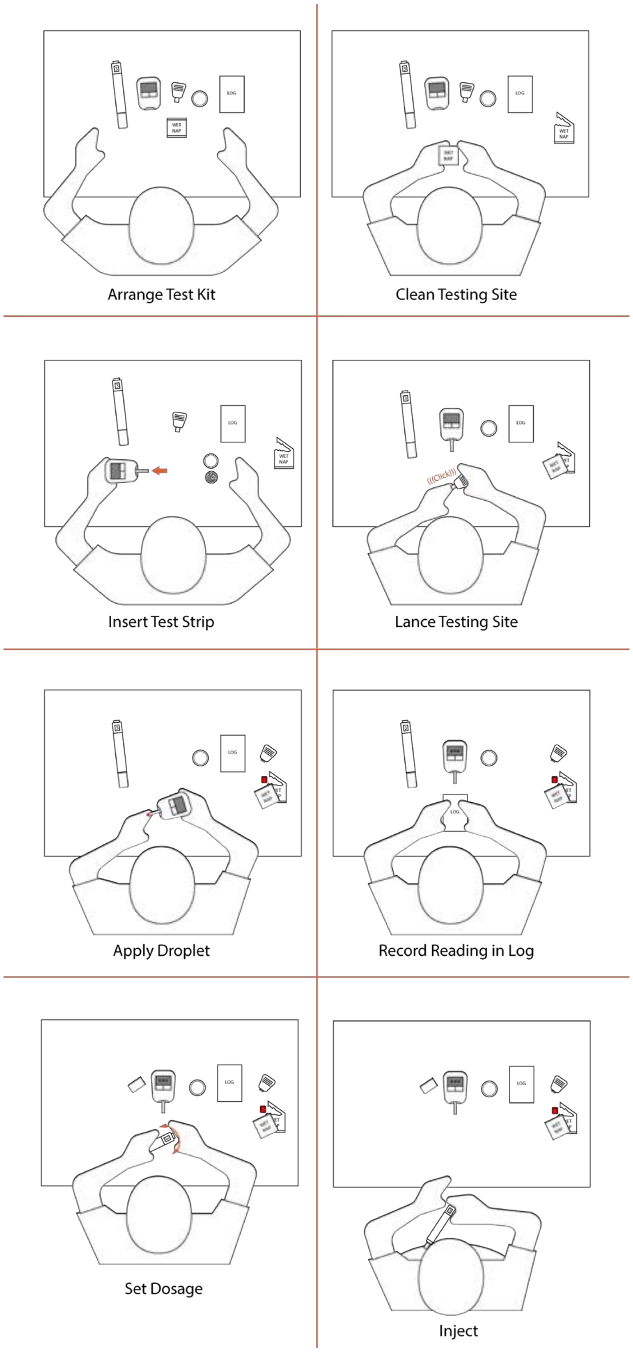
Movement and user interactions

- How is it gripped?
- How many times is the grip adjusted?
- Does the user ever have to re-grip?
- Make note of the following:
  - Awkward or uncomfortable postures
  - Signs of fatigue

Final storage or disposal

- What is done with the product after use?

Measure and record the user's hand size at the end of the use case observation to reference in later processes.



Arrange Test Kit

Clean Testing Site

Insert Test Strip

Lance Testing Site

Apply Droplet

Record Reading in Log

Set Dosage

Inject

Figure 1: Task analysis storyboard example

Once you have documented how several individuals use the product, review your written observations or videos to note the most common grip postures. To capture grip postures more accurately, you should observe and chart estimated joint angles in use, as shown in Figure 2. In addition, note patterns of grip adjustment or re-gripping, awkward postures, signs of fatigue and interfaces that cause frustration.

Ask the individuals to bring in a competitive device they currently use. Review the device for evidence of grip wear that might indicate pressure points and other areas where applied grip force is concentrated.

Next, based on the most prominent postures, simulate the use case to record all **measurable forces** the user will experience in each. Figure 3 illustrates how identifying the postures and forces will dictate the grip architecture needed to perform a task. Be sure to identify the applied force vectors and measure, if possible, after the observation exercise. In this drill example, a table shows the potential value for each force, including the force pulling down on the weight of the drill (gravity), the force of the user pushing in the material being drilled, the force of the trigger being pulled, and the torque of the motor trying to rotate the drill and drill bit. Based on the magnitude of the force values and vectors (directions), a power grip is determined to be optimal for the given task.

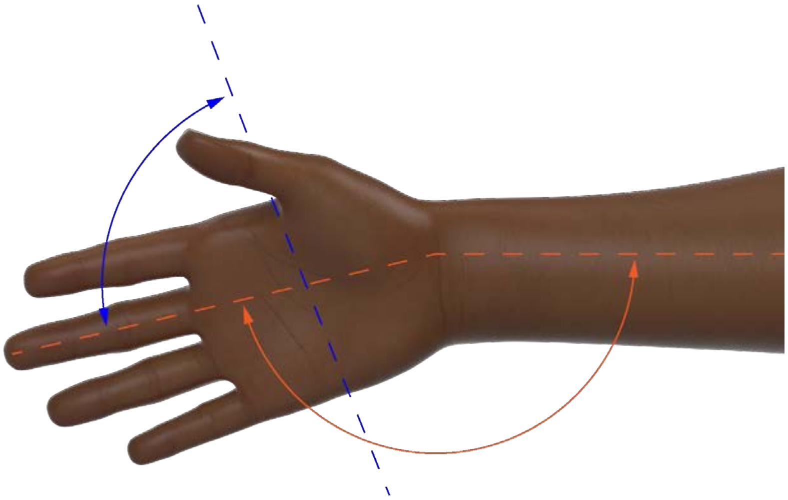
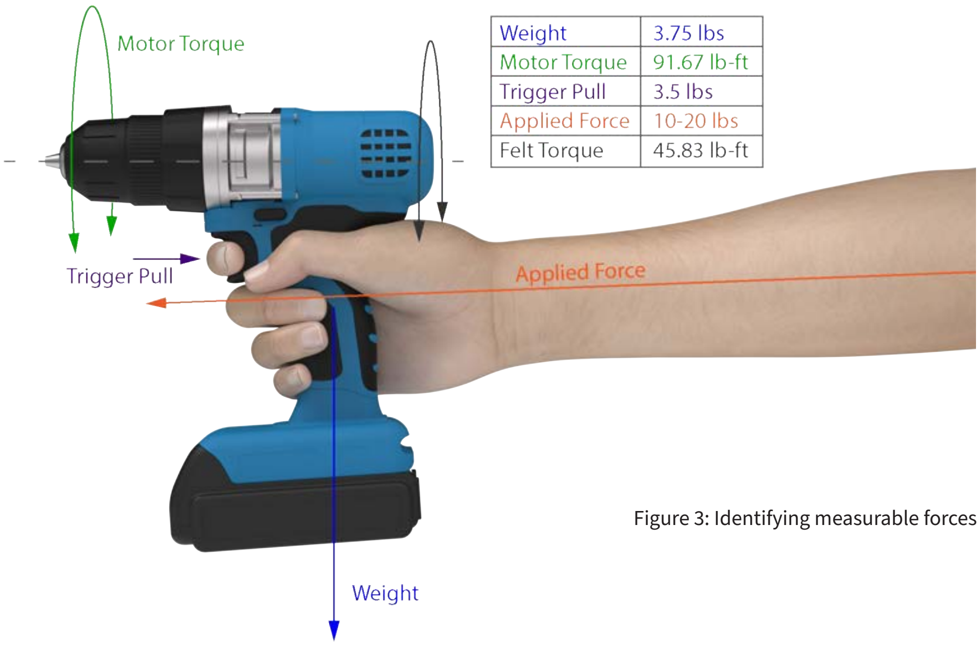


Figure 2: Grip posture observations



Weight	3.75 lbs
Motor Torque	91.67 lb-ft
Trigger Pull	3.5 lbs
Applied Force	10-20 lbs
Felt Torque	45.83 lb-ft

Figure 3: Identifying measurable forces

DEFINING THE USER

Once you have defined the use case and identified measurable forces, move on to defining the target user for the device. The more specific you can be, the more accurately you can design the grip.

For example, Figure 4 shows how three types of people use different methods to grip a toothbrush.

This focus on the user should, at a minimum, include age range and ratios, gender ratio, and specific physical, cognitive and sensory limitations (particularly for medical or pharmaceutical devices). Examples of physical limitations include tremors, reduced dexterity and arthritis.

Figure 4: Observed grip methods

Figure 5: Hands affected by arthritis

DEFINING THE ANTHROPOMETRIC DATA

The final step in establishing grip requirements is defining the anthropometric data for the target user and use case. You can find many published resources such as **"Hand Anthropometry of U.S. Army Personnel"**, a report by Thomas M. Greiner. Such documents provide average sizing data and acceptable force data for specific hand measurements and generalized grip types. Figure 6 illustrates the considerable size difference between a 5th percentile female and 95th percentile male hand.

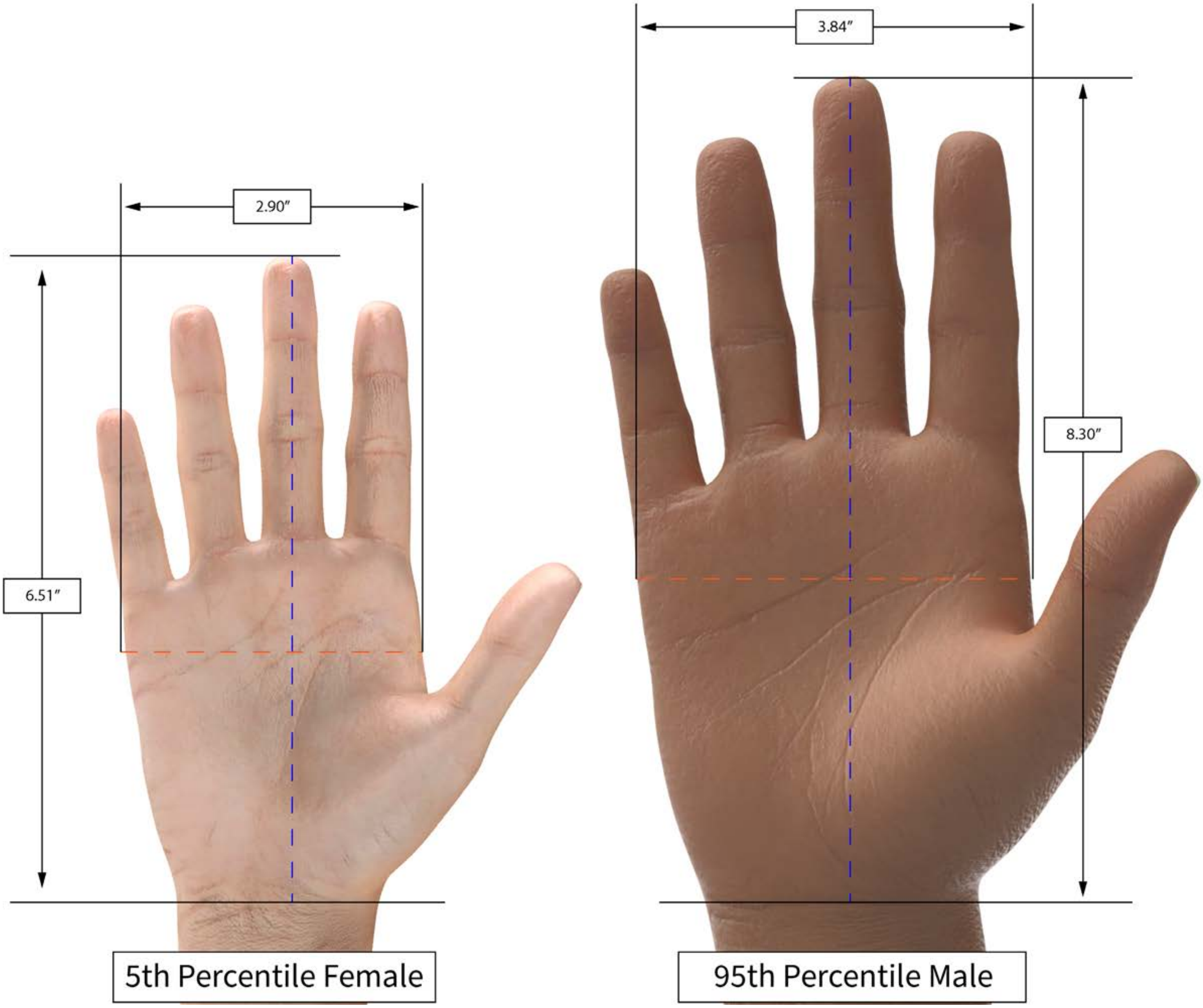


Figure 6: Comparison of hand sizing data

DEFINING GRIP ARCHITECTURE

After defining the anthropometric data, create a design brief outlining your deliverables and scope of work. This brief can now be used to develop the grip architecture and overall layout of the device.

Five basic **grip architectures**, shown in Figure 7, can be used as a starting point for selecting the appropriate type of grip.

1. **Power grip** - The power tool or pistol grip uses the large muscles of the forearm to provide the highest possible grip force, but offers limited dexterity.
2. **Spherical grip** - This palm grip with the fingers wrapping an object, such as a doorknob or ball, uses the forearm muscles while allowing limited manipulation by the fingers.
3. **Key grip** - This lateral pinch grip style, typically used for objects such as keys, primarily uses the muscles of the thumb opposing the curled fingers. It is a typical grip type for people with severe arthritis.
4. **Pinch grip** - The tip-pinch or two-point grip is used for picking up objects, such as a coin or credit card. It utilizes the intrinsic muscles of the hand, which are four muscle groups that work together to provide dexterity and fine motor control to the fingers and thumb.
5. **Pencil grip** - Also known as a tripod or chuck grip, this configuration uses the three smart digits (index finger, middle finger and thumb) to control and manipulate the object. It is typically used for high-precision tasks such as writing, drawing and making incisions.

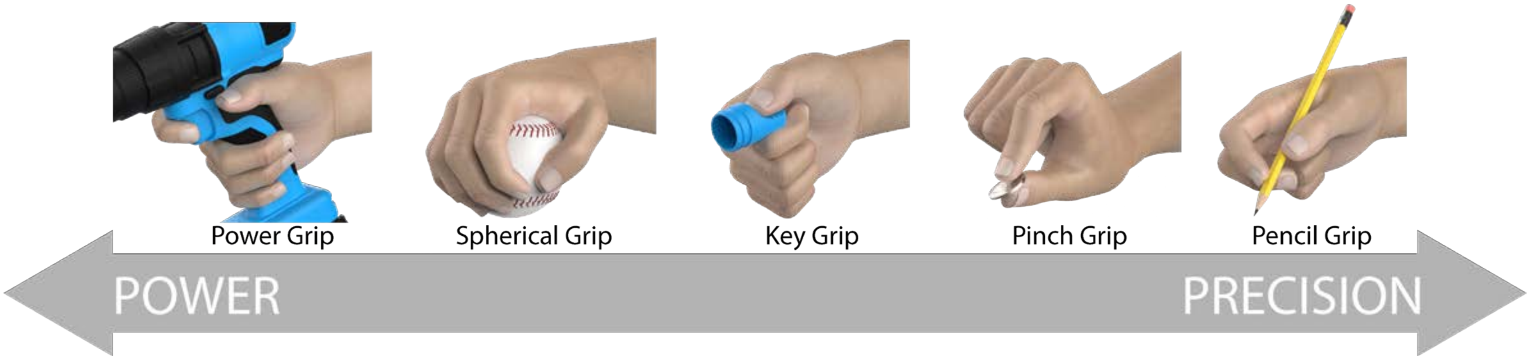


Figure 7: Basic grip architectures

Grip selection always involves tradeoffs between power and precision. For power, the larger muscles of the forearm need to be activated. For precision, the smaller muscles of the fingers need to be in control. Beyond finding the ideal balance of power and precision, consider which fingers are needed to manipulate controls and stabilize the product.

After identifying the basic grip architecture, you should focus on optimizing the design based on contours, weight and balance, material hardness, and duration of use.

CONTOURING involves shaping the grip to complement the architecture and intuitively guide the user to the proper posture and touchpoints. A key goal of contouring is to reduce the amount of grip force needed to hold the device. To do this, the contour and design elements must work together to enable all possible forces encountered during use. The direction of forces will help to shape the form and even manufacturing details of the grip.

Contours can provide **interlocks** for the fingers to reduce grip force and improve comfort. For instance, a screwdriver must provide good interlocks longitudinally, along the axis, as well as axially. A basic ergonomic screwdriver handle profile with three distinctive contouring methods is shown in Figure 8.

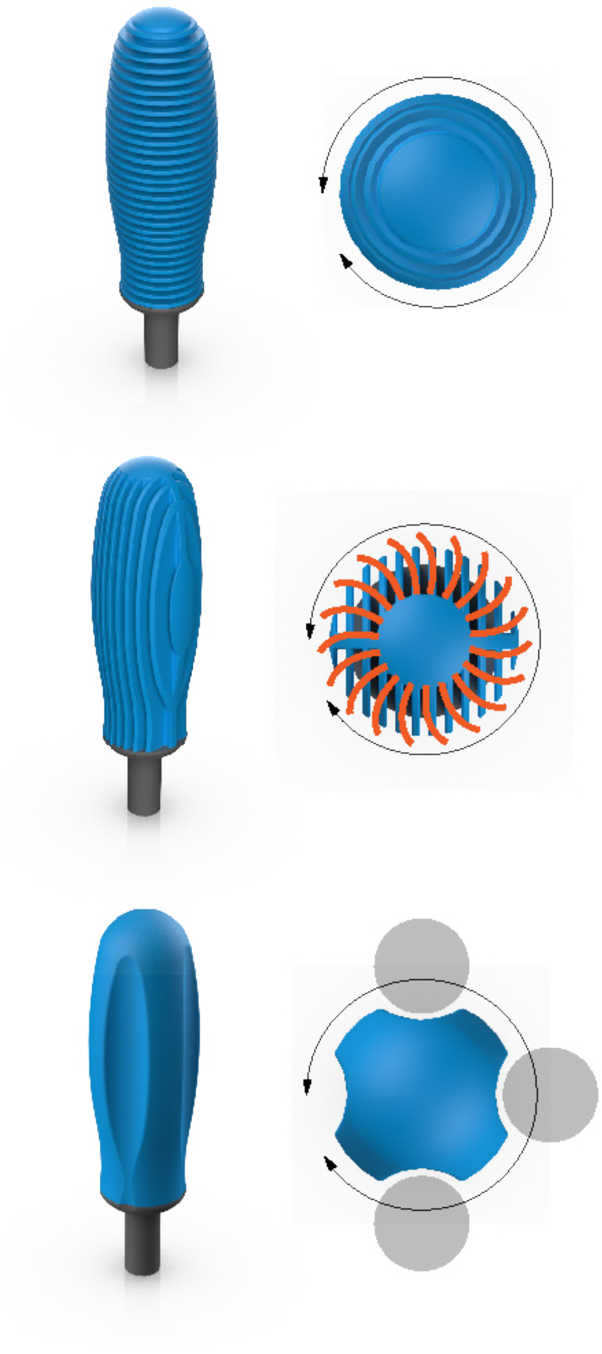


Figure 8: Example contouring methods

Method A: The handle is cored out for optimal wall thickness. The radial coring provides a comfortable grip contour; however, it provides no interlocks for resisting axial loads. The result is increased application of grip force during use.

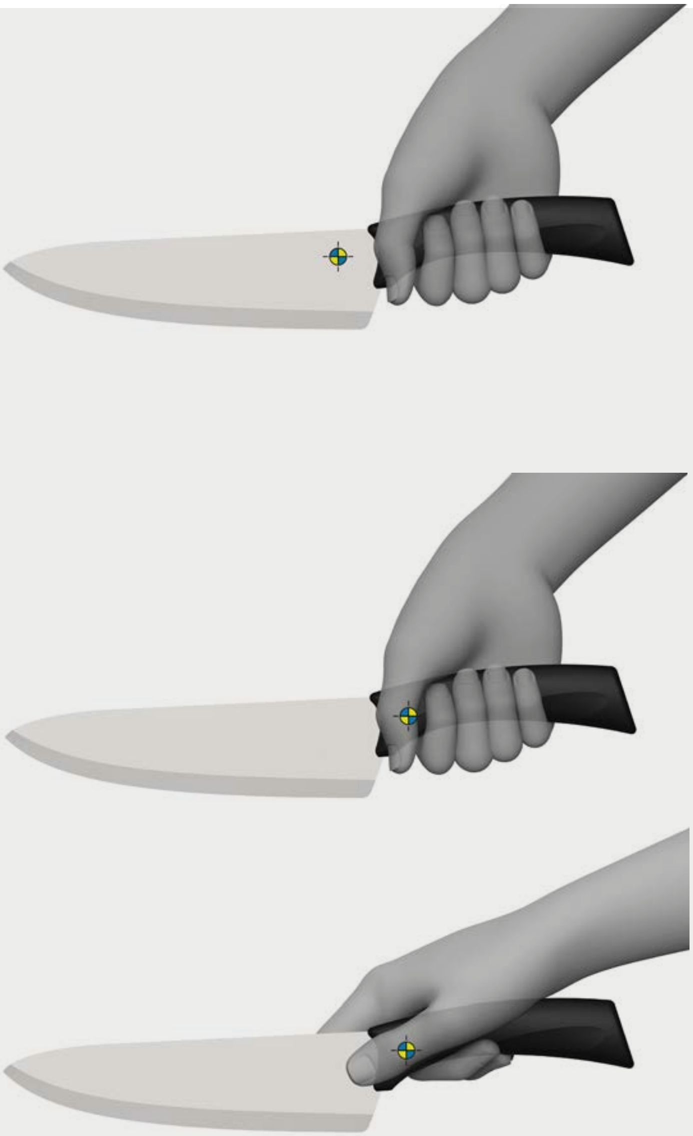
Method B: The same handle profile is again cored out for optimal wall thickness. The longitudinal coring also provides a comfortable grip contour; however, the thin walls of the elastomeric ribs collapse under axial loads. This design requires the user to exert more grip force.

Method C: The same handle profile is given flute cuts that provide ample interlocks for applying and resisting axial loads.

WEIGHT AND BALANCE can improve handling as well as the perception of quality.

While heavier weight can increase fatigue, if it is strategically and correctly placed, additional weight can improve dexterity. It's important to understand and fine-tune the **balance points** and weight distribution of your product. Figure 9 shows how shifting the **center of mass (COM)**, indicated by the circle target, through weighting can provide better balance and comfort.

As an alternative to metal and metal inserts, **high-density plastic materials** with customizable specific gravity, which can range from 1.5 to 11, can be used for weighting and balancing. Plastic molding technology gives you the ability to add weight directly into customized and complex forms.



A design with an unfilled plastic handle—in which the polymer contains no fillers—pushes the COM toward the blade, making the knife feel unbalanced in a power grip.

Overmolding a density-modified plastic onto the handle increases its weight and shifts the COM back towards the grip. This shift helps to make a power grip feel balanced, and would enable the use of other grip styles.

Figure 9: Center of mass comparisons

MATERIAL HARDNESS (DUROMETER) is key to grip security and fatigue reduction.

Durometer is the international standard for measuring the hardness of rubber, plastic and other nonmetallic materials. It is determined by the depth of indentation in the material by a given force for a set time.

Applying soft-touch materials strategically using overmolding can help reduce required grip strength and contact pressure. These materials can also provide vibration damping or impact protection.

In overmolded applications, the thinner the layer of elastomer applied on the substrate, the harder it will feel. This perception is known as the **apparent hardness**. It's important to select the right durometer as well as the appropriate thickness to achieve the desired grip and feel. Figure 10 shows the apparent hardness of thermoplastic elastomers (TPEs) with different durometers, measured at different thicknesses. The loss of a soft-touch feel in thinner overmolds will be especially pronounced in low-durometer materials such as the 3, 13 and 33 Shore A materials shown in Figure 10.

A cut-out view shows the hard plastic substrate and the overmolded soft-touch TPE.

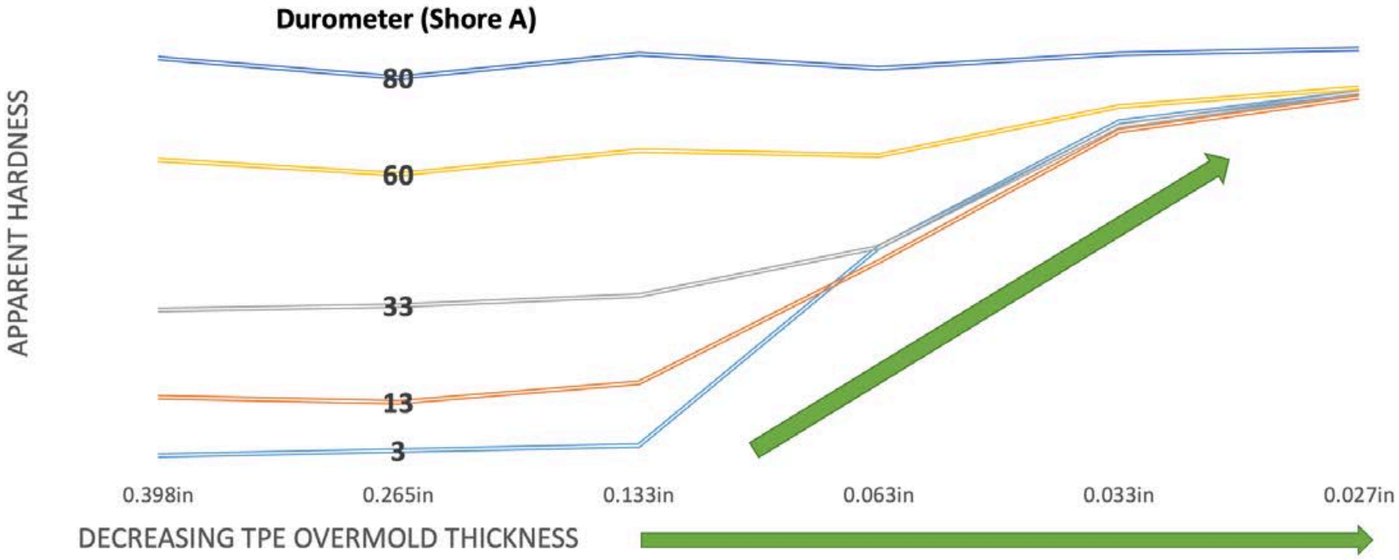


Figure 10: Thickness and the corresponding apparent hardness

DURATION OF USE is an aspect of grip that, while sometimes overlooked, plays a major role in design decisions.

The **duration of use** and the **frequency of use of a handheld device** should significantly influence its design. As you might expect, duration of use is inversely related to grip strength.

To demonstrate, Figure 11 shows how the mean strength of people with multiple sclerosis (PwMS) during a 30-second, sustained contraction is normalized to their maximal hand grip strength and compared to healthy controls. Figure 12 shows the relationship between smartphone usage duration (in hours) and handgrip strength (in kilograms) in young people. It also reveals longer durations of average daily smartphone usage were correlated to weaker handgrip strength.

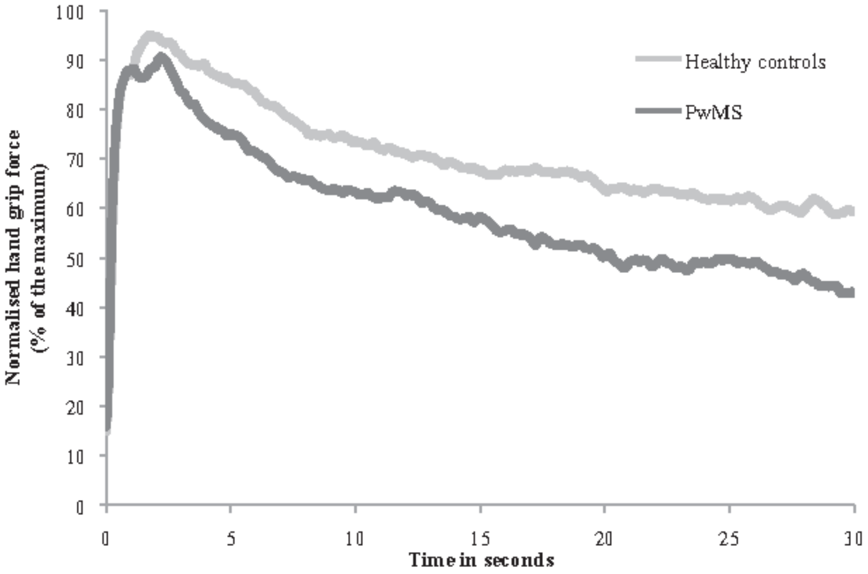


Figure 11: Duration of use

Journal of Rehabilitation Medicine, 47 2 (2015): 154-60.
https://doi.org/10.2340/16501977-1897

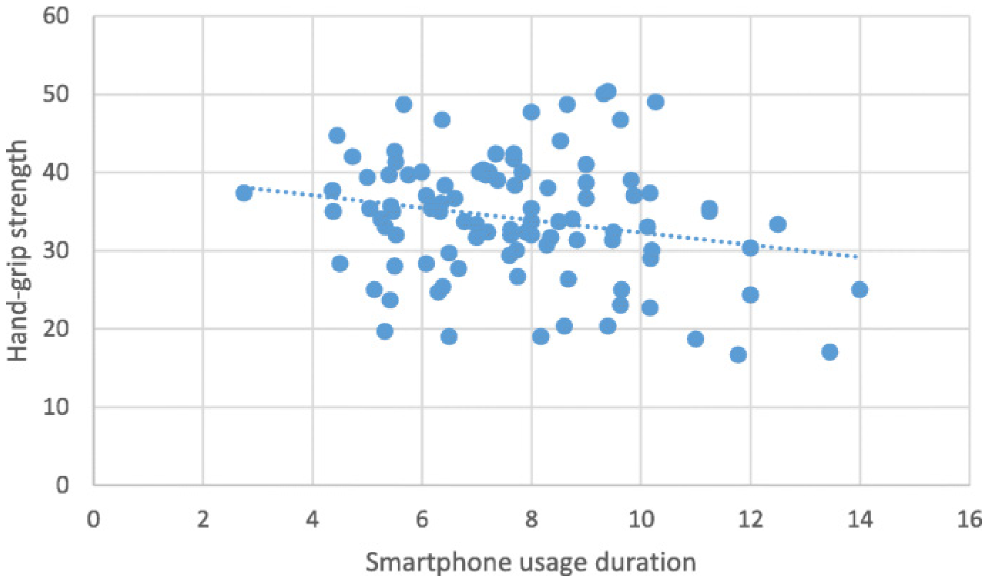


Figure 12: Duration of use

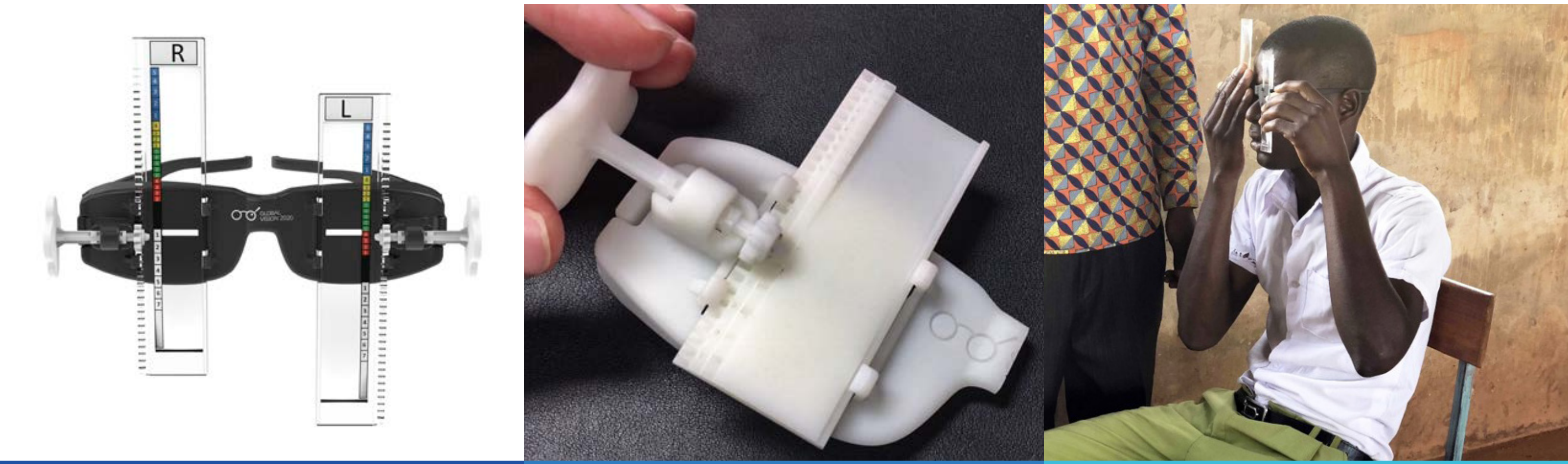
BMC Musculoskeletal Disorders 2021 22:186.
https://doi.org/10.1186/s12891-021-04054-6

VALIDATING THE DESIGN PRE-PRODUCTION

Pre-production validation of the conceptual design is paramount in reducing the overall risk of the program.

Prototypes with a realistic look and feel play a key role in **user-centric validation sessions**. They not only help to validate the form and usability of the proposed design, but also help designers catch small oversights or usability issues that may not have been apparent with existing products. Use validation sessions to dry run motions and use scenarios.

Figure 13 illustrates the design of the USee™ vision correction system, shows a prototype, and gives an example of user testing that helped to fine-tune the final design.



The USee™ is a simple yet effective plastic self-refraction device that enables low-cost vision correction in under-resourced communities.

An early 3D printed prototype tests the one-sided gear mechanism that moves the curved lens to dial in the best corrected visual acuity.

Prototypes were used in field and clinical testing for real-time feedback and iterative design adjustments.

Figure 15: USee™ validation process

DESIGNING FOR THE PRODUCT ENVIRONMENT

OPTIMIZING GRIP PERFORMANCE

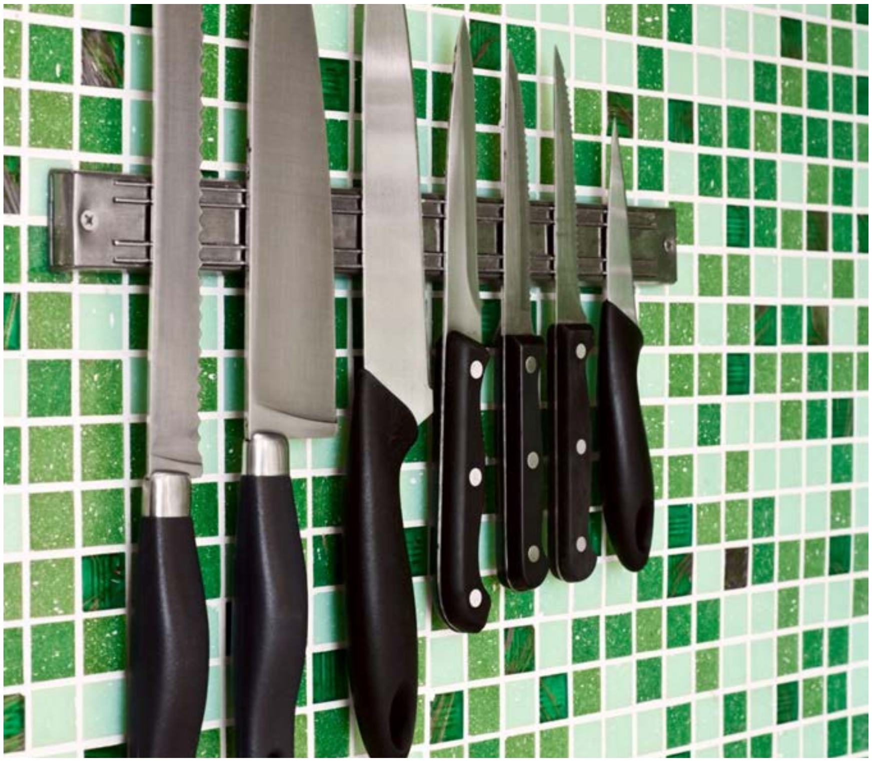
The environment where the device is used can have a huge influence on grip performance. Important environmental factors to consider include temperature, contacting materials and texture.

Temperature - Grip strength decreases in hot and cold temperature extremes. You should carefully consider what effect the ambient temperature will have on device usability, particularly in demanding environments such as manufacturing, agriculture, building and construction, and medical/surgical settings.

To accommodate extreme temperatures, you can use a plastic material with a **tackier chemistry** to compensate for loss of grip strength and prevent slipping.

Contacting materials - Water and other fluids can add slip or make your device's grip less reliable. To address this issue, you can design with softer materials over a greater surface area. Specially formulated materials for **wet grip** are designed to provide a greater **coefficient of friction (COF)**. Figure 14 illustrates the wet/dry COF performance of a wet grip TPE compared to other commonly used materials. In the case of grip contact with body fluids, lipids or oils, reducing hardness is less of a factor than selecting the right **surface texture**.

Gloves can decrease grip strength compared to bare hands. Consider the material and thickness of the gloves that will be used to operate the device. Here, grip texture is also a big factor in helping gloved hands adhere to the device. Design the grip texture to bite into and hold the glove.



Grips for devices designed for use in commercial kitchens need resistance to lipids and fatty foods.

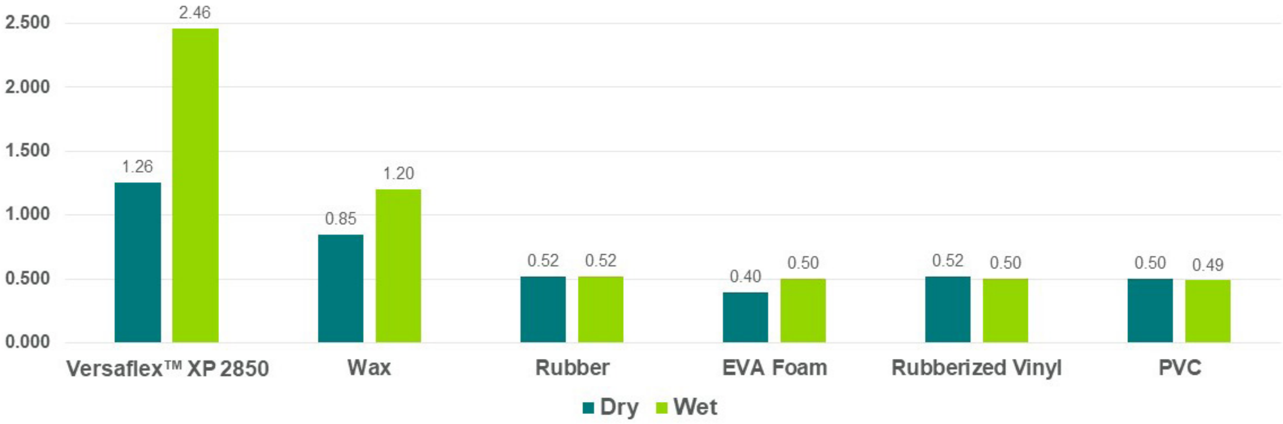


Figure 14: Wet/dry COF performance of wet grip materials

Texture - Selecting the right texture is a big factor in improving the suitability of the design to the environment. Beyond helping with ergonomics, texture is key for processability and efficiency. For instance, it improves **production speed** by helping to release the part from the mold faster.

Finding the right texture may require balancing design, performance and processability. For example, a handle well designed for wet grip with softer durometers, more surface area and an aggressive texture could make the part more likely to stick to the mold.

Larger textures combine grip functionality and distinctive aesthetics for product differentiation.

Heavy textures are ideal for gloved use, allowing the texture to bite into the glove material for increased grip. However, prolonged use of a heavy texture without gloves can result in discomfort and hand fatigue.

Lighter textures work well in a variety of general-purpose scenarios where the device does not require high grip strength or prolonged use. These textures are also well suited for non-gloved hands because they provide increased grip without causing discomfort.

Gloss or semi-gloss textures are often used for highly aesthetic surfaces. They generally provide the least friction. However, part design can enable glossy textures to provide a functional grip surface.

Figure 15: Four common textures and their typical uses

DESIGNING FOR DURABILITY

Material chemistry and durometer are determining factors in the durability of your device's grip.

Figure 16 shows an **abrasion test** where two abrading wheels rotate in opposite directions against a flat specimen of material. Mass loss calculated from this test indicates the abrasion resistance, or durability of the material. Figure 17 is a bar graph of mass loss for a variety of GLS™ TPE grades according to ASTM D3389.

Figure 16: Abrasion test

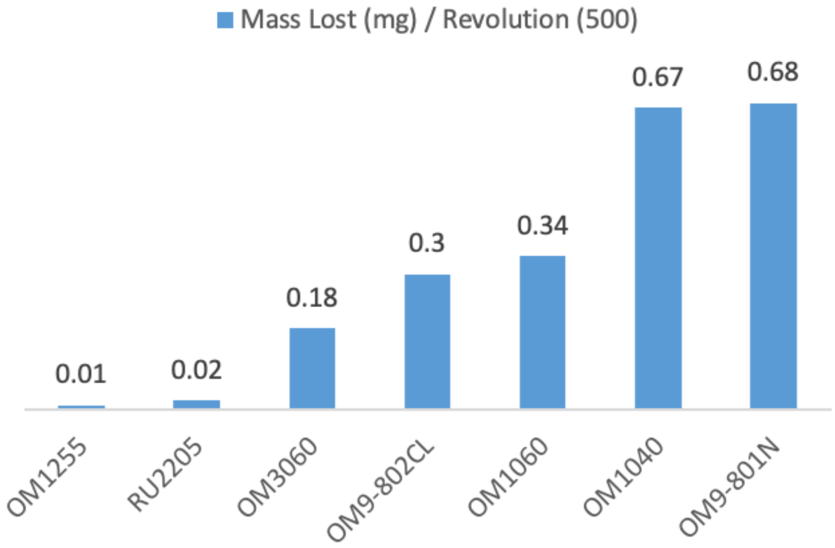


Figure 17: Mass loss test results

The movement of the abrading wheels replicates rubbing, allowing this test to be used for evaluating resistance to variety of surfaces, including materials containing dyes. Figure 18 shows how Versaflex™ CE 3320-70 TPE resists staining from rubbing against blue jean material containing dye. This TPE offers the same resistance to staining as silicone, but with increased design freedom and supply chain flexibility at reduced cost.

Figure 18: Blue jean stain resistance testing

It’s important to note that abrasion resistance can be improved through changes in material formulation. Further, material durability can be optimized by selecting polymer formulations with a high **resistance to environmental factors** such as UV light, chemicals including salt water, acids and plasticizers, temperature extremes from boiling, autoclaving and automatic dishwashing, and unintended storage stresses like exposure to heat in a car trunk.

UTILIZING ENGINEERING SIMULATIONS

Engineering simulations with advanced computer software can be used to evaluate a variety of product performance criteria and address important questions related to ergonomic design. Simulations can provide new insights and perspectives before and in conjunction with physical testing, helping to save project time and costs. Computer-aided engineering (CAE) is an effective method for simulating performance to improve design and optimize products and processes.

HAMMER HANDLE CASE STUDY

Avient Design, a team of industrial designers and project engineers, used CAE simulation to provide a **proof of concept for converting from a standard steel or wood hammer handle to a polymer design**. Anticipated benefits from the conversion included improved cost efficiencies and aesthetics, greater design freedom and product differentiation. Key components of this simulation are part model, material model, physics, load and boundary conditions and output.

CASE STUDY OBJECTIVE

Computationally evaluate whether the new polymer design has comparable or improved performance in:

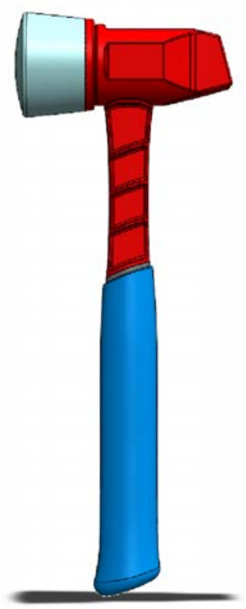
- The impact or reaction force felt by the hand (comfort)
- The vibration frequency transmitted to the hand (safety*)

*Repetitive vibration frequencies in a handheld product have been known to lead to neuromuscular issues including dexterity loss and nerve deadening.

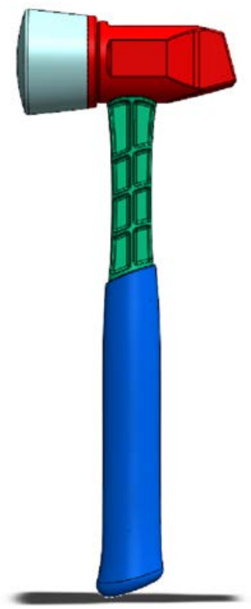
PART MODEL (GEOMETRY AND MESH)

Avient Design began the setup for the simulation with 3D CAD models for each of the hammer handle designs. These models were meshed in finite element analysis (FEA) software to define the shape of the object.

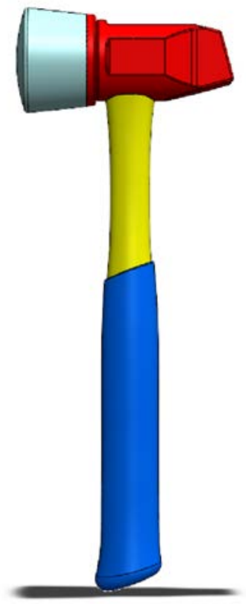
Standard designs for steel and wood hammer shafts were compared to a new polymer shaft designed for injection molding. The team selected a long glass fiber-reinforced nylon material (Complēt™ PA66-LGF50 composite) for the shaft substrate to provide strength and to withstand hammering impact. Epoxy and nylon plugs were used for the ends. All three designs featured an overmolded soft-touch TPE to add security to the grip and reduce the impact force felt by the hand.



Steel hammer shaft



Polymer hammer shaft



Wood hammer shaft

MATERIAL MODEL

The team entered material data relevant to ergonomic performance into the FEA software to complete the model. For the vibration study, data on elastic modulus (stiffness), density and vibration damping factors were required for modal and harmonic analysis. A stress-strain curve was used to extract the stiffness value for the Complēt™ material. Data for the other materials came from technical data sheets or literature. The team estimated damping factors using typical measurements for the three materials. Material data used in the simulation are shown in Figure 19.

Material	Stiffness (MPa)	Density (g/cc)	Damping factor (-)
Steel	210000	7.850	0.10%
Complēt™LGF	21000	1.600	3.00%
Wood	12322*	0.697*	2.26%*
Nylon	3000	1.150	6.00%
Epoxy	2813**	1.180**	3.00%
TPE Overmold	500	1.000	50.00%

Figure 19: Material data Inputs

* http://www.scielo.org.mx/pdf/remcf/v9n48/2007-1132-remcf-9-48-181-en.pdf
** https://www.westsystem.com/products/compare-epoxy-physical-properties/

PHYSICS

After setting up the part and material models, the team determined applicable physics for the study. For the modal and harmonic analysis, their first step was to evaluate the eigenmodes, or the natural vibrations of the system, and determine which ones were relevant to the study. In Figure 20, the first three eigenmodes and their respective eigenfrequencies (Hz) for the hammers are described.

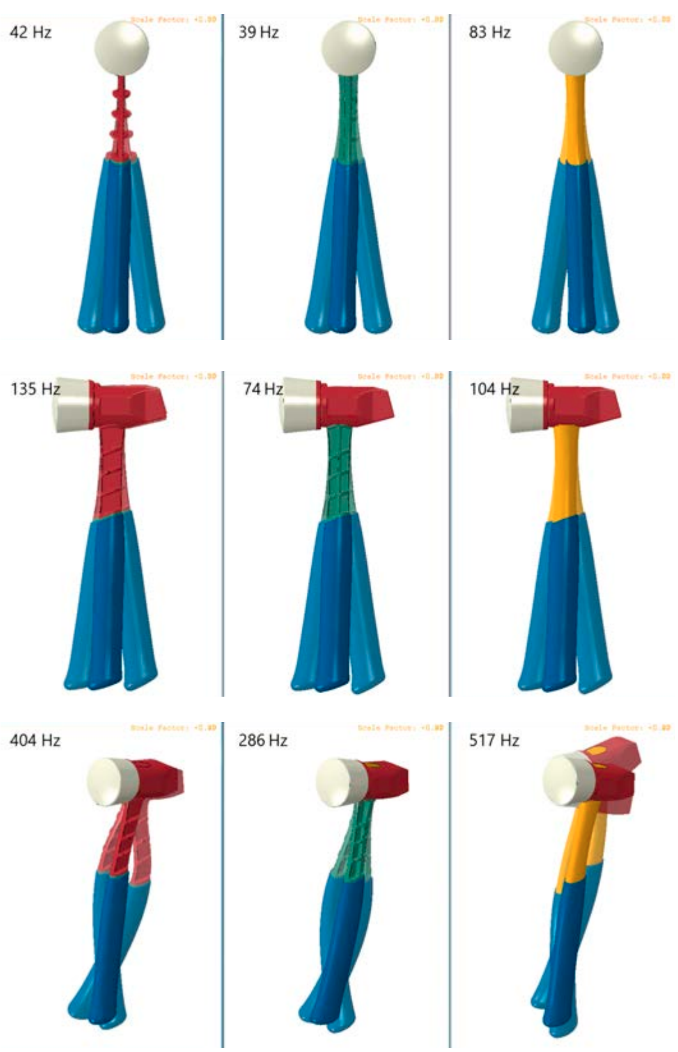


Figure 20: Eigenmodes and eigenfrequencies for hammer shafts (left to right: steel, polymer, wood)

Mode 1
Eigenfrequencies in the side-to-side motion.

This mode was of some interest for the hammering action.

Mode 2
Eigenfrequencies in the forward-and-back motion.

This mode was of highest interest, as it moves in the direction of the foreseen forces of the hammering action.

Mode 3
Eigenfrequencies in the up-and- down motion.

This mode was of least interest for the anticipated action.

The evaluation determined that modes 1 and 2 were pertinent to the hammer action because they best aligned with the most common directional use. Therefore, the physical parameters of this study focused on 0-200 Hz, well above the highest frequency in Mode 2 for any of the hammers.

LOAD AND BOUNDARY CONDITIONS

Next, the team set load and boundary conditions as necessary constraints to enable the simulation solutions. The setup was completed by fixing the impact surface of the hammer and applying a 1g (gravity force = 9.8 m/s/s) excitation in the X-direction, as shown in Figure 21.

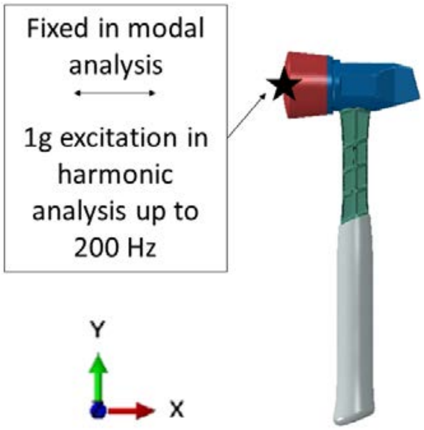


Figure 21: Fixed modal analysis

OUTPUT

The design team evaluated the force transmitted to the handle. The outputs of transmitted reaction force and acceleration gain are illustrated in Figure 22.

Reaction force (N) transmitted to the handle was plotted. It showed less force is transmitted to the hand by a polymer hammer shaft than a steel one.

A wooden hammer shaft shows similar or lower force transmission vs. the polymer hammer shaft.

Acceleration gain transmitted from the excitation at the hammer impact area to the end of the hammer handle was plotted.

The polymer hammer handle exhibited the lowest acceleration gain, followed by the wood shaft and then by the steel one.

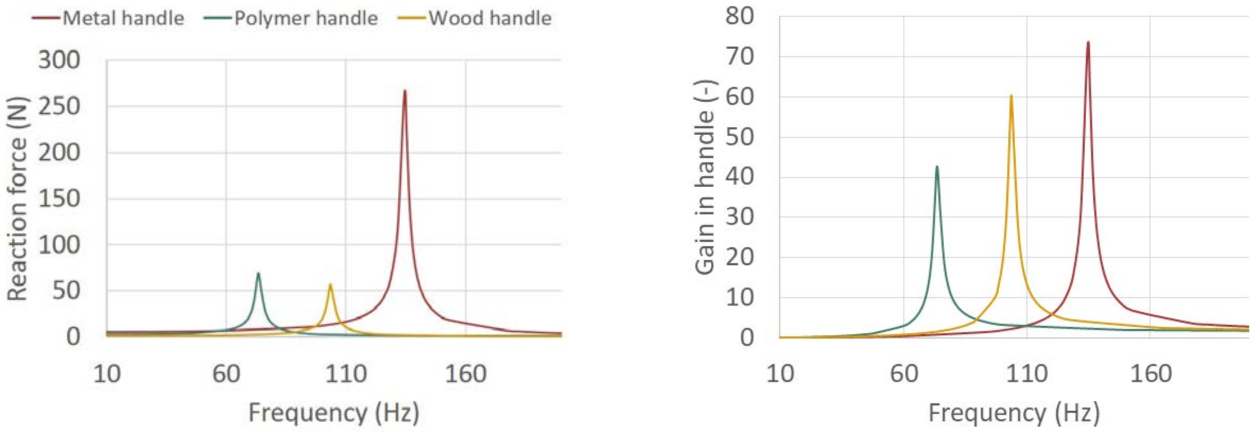


Figure 22: Transmitted reaction force and accelerated gain

Lower acceleration gain is desirable to reduce the risks of hand-transmitted vibration. However, the acceleration gain reported in Figure 22 occurred at different natural frequencies for each of the handle materials. Therefore, these gains had to be balanced (or ponderated, where the results are weighted against a standard) as a function of the frequency at which they occurred in order to understand the true impacts on health and safety.

Testing standards may vary by country. The materials in this case study were ponderated using the International Organization for Standardization (ISO) recommendations. When the accelerated gains were weighted as a function of the frequency, the polymer handle had either a similar accelerated gain (ISO 5346-1:2001) or a lower gain that reduced the risk (ISO 18570:2017). The material comparison test results are shown in Figure 23.

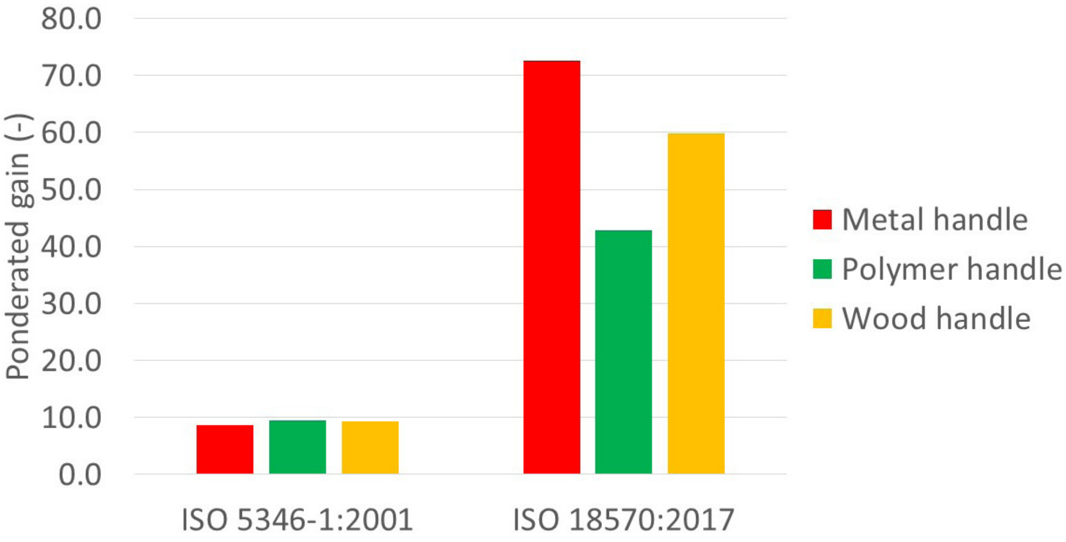


Figure 23: Ponderated acceleration gains

CASE STUDY CONCLUSION

This engineering simulation case study successfully demonstrated proof of concept for replacing traditional hammer shaft materials with the proposed polymer. Based on scientific parameters related to user comfort and safety, the polymer handle demonstrated lower transmitted impact force compared to steel, and similar transmitted impact force compared to wood. The impact of vibration and 'felt' accelerated gains of the polymer handle were either comparable to the other materials or much improved, according to two international standards.

Using simulation software reduced iterations, aided in decision making and increased confidence in the solution's ergonomic benefits. By providing quantitative data and information, the software helped to avoid rounds of physical testing (requiring physical prototypes, pneumatic motors and accelerometers) that would have affected the project's timeline and cost.

DESIGNING FOR SUSTAINABILITY

With sustainability in mind at the beginning of product design, the result can be a product with improved ergonomic elements and functional performance that also helps to reduce environmental impact through the choice of sustainable materials, a reduction in resource usage, and the optimization of end-of-life options.

When following an ecodesign strategy, it’s important to consider the many system elements together when making design, material and production decisions. We cover a few ideas in this section.

MATERIAL STRATEGIES

To minimize the quantity of resources required to produce a device, you can look for durable materials that extend the product’s useful life and use simulation software with topology studies in conjunction with FEA technology to identify overengineered areas or the unnecessary use of material. Try to design for low-consumption behavior to nudge the user toward less-wasteful habits.

Selecting **recycled or reclaimed** materials is a popular strategy for improving sustainability.

New polymers containing recycled content are being developed to reduce carbon emissions, energy usage, waste and pollution. These materials may offer comparable or improved performance compared to traditional polymers, and provide cost benefits as well.

Another option is to use materials made with renewable resources. For instance, **bio-polymers** are based entirely or partially on renewable sources such as sugarcane, and may perform at a level comparable to conventional polymers.

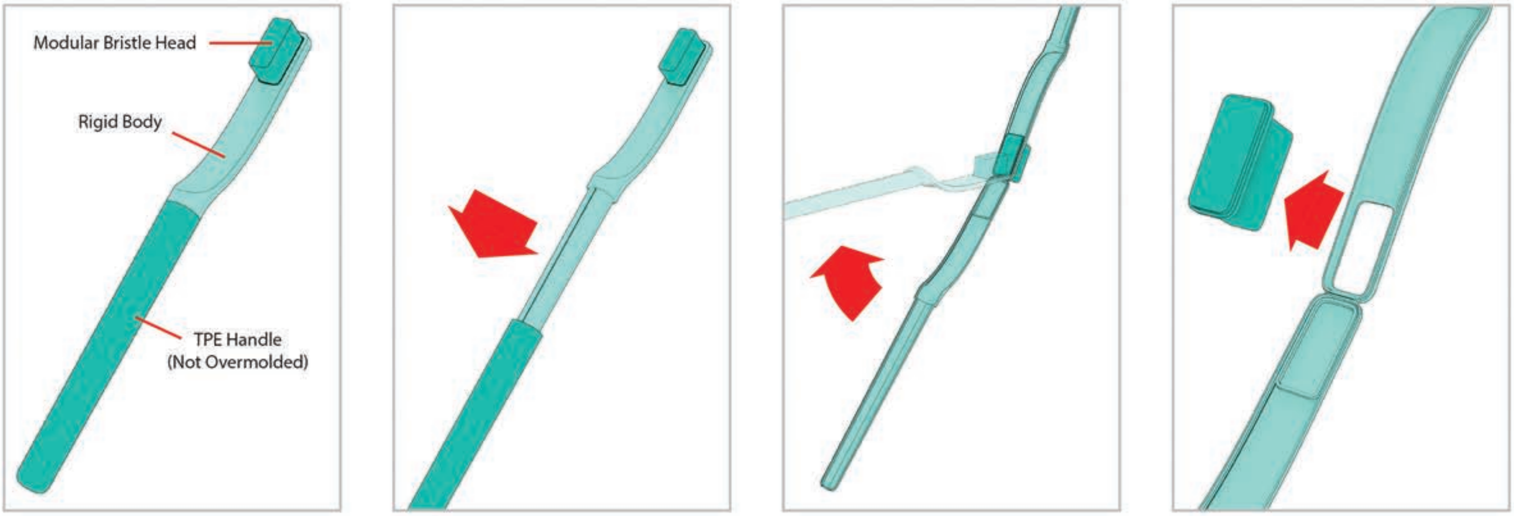
DESIGN STRATEGIES

As we stated above, increasing the durability of a device can help extend its useful life and reduce waste. Along with choosing durable materials, designing for high quality and efficient operation can play a role in product longevity. Design can also improve the ease of reusing or replacing device components to avoid discarding the entire product.

Design can also influence the environmental impacts of transportation and distribution. Product **lightweighting to reduce fuel consumption and emissions** can be achieved by streamlining the design, using lighter materials and consolidating parts. Improving **packing efficiency to fit more products in a given space** can optimize transport and storage.

A major environmental issue is **optimizing a product's end-of-life options**, ranging from disassembly to recycling and disposal. Considerations include the ability to reduce components to monomaterials that can be recycled readily, or to include parts in the recycle stream with other materials. For example, a TPE part such as a gasket may be recyclable with different materials provided it complies with volume thresholds.

Figure 24 uses the example of a toothbrush design to illustrate how a sustainable mindset can be applied to product design.



Panel 1 summarizes application of ecodesign to the toothbrush.

Panel 2 shows the TPE handle, a separate molded part that slides onto the body rather than being overmolded, allowing both components to be separated and easily recycled.

Panel 3 shows how the slide-on TPE handle secures the body to the toothbrush, which consists of a single molded component with a living hinge that folds to create the overall form.

As shown in Panel 4, the body and handle are reusable to reduce waste, and the bristles are attached to a small modular component that can be replaced as needed.

Figure 24: Applying an ecodesign approach

UNDERSTANDING PRODUCT REGULATIONS

It's important to understand relevant product regulations and how they can impact the suitability of material formulations for your device. Many regulations aim to prevent or minimize damage to human health and the environment. This helps to mitigate the risk of product impacts to the health of people and to the environment. Avoid materials that may damage human or ecological health.

Below are some regulations and possible questions related to common end markets of ergonomic devices.

Healthcare device regulations

- How is the device classified for the final region of sale? (US FDA, EU MDR, EU IVDR)
- Is biocompatibility required or will it be tested for?
- Are animal derivatives, phthalates, nanomaterials or CMR (carcinogenic, mutagenic, or toxic to reproduction) substances of concern?

Food contact applications

- For direct food contact, what regulations may be relevant? (US FDA, EU 10/2011, China GB, Japan PL, Mercusor for certain countries in South America)
- What types of food will be contacted and under what conditions/temperatures?
- Are any substances of concern an issue? (animal derivatives, phthalates, BPA, allergens, GMOs)
- Will this device be used in a commercial kitchen where NSF (National Sanitation Foundation) compliance (e.g., NSF-51 for food equipment) will be required for the material or the final part?

Common regulations

- REACH SVHC, RoHS 3 (EU 2015/863), CA Prop 65, Heavy Metals (CONEG, 94/62/EC) and Conflict Minerals
- Substances of Concern (could include phthalates, latex, PVC, BPA, halogens, PAH, flame retardants)

Other market-specific regulations

- Consumer Product Safety Improvement Act of 2008 (CPSIA)
    - Lead and phthalate limits for products designed for children
- Chemicals of High Concern for Children (CHCC)
    - Several US states (OR, WA, VT, ME, MN) have lists of chemicals of concern for products designed for children
- Global Automotive Declarable Substance List (GADSL)
    - Specifically for automotive applications
- End of Life Vehicles (ELV) Directive, 2000/53/EC
    - Restrictions on certain heavy metals for . automotive applications
- EC1223/2009
    - Covers prohibited, restricted substances in cosmetic products

This list is not exhaustive and regulatory requirements change and evolve. It's advisable to consult with a quality, regulatory or product stewardship expert to understand what regulatory requirements apply to the materials used in your final application. Material suppliers can provide documentation of compliance with substance restrictions.

FACTORING IN EMOTIONAL AND PSYCHOLOGICAL ELEMENTS

Our perceptions of device usability and performance can be tied to our feelings and emotions regarding the design, quality or tactile experience of handling and using a product.

Form, color and feel all help to **differentiate premium products**. These design elements can generate greater market appeal and also justify a higher price point. Figure 25 shares the price differential observed at a big box store between common household items with and without TPEs used in grips.

Good design can also aid sustainability and encourage low-consumption user behavior. As shown in Figure 26, applying form, color, and feel can create a timeless aesthetic and help foster a user's emotional connection to the product while also contributing to the product's success and furthering sustainability goals.

PRODUCT	WITH TPE	WITHOUT TPE	% CHANGE
Tape Measure	20.99	11.99	43
Ice Cream Scoop	5.99	4.99	17
Shaving Razor	1.30	0.75	42
Mechanical Pencil	0.50	0.29	48
Cork Screw	7.99	6.99	13
Pizza Wheel	6.99	4.99	29
Can Opener	8.99	5.99	33
Utility Knife	10.99	5.79	47

Figure 25: Price comparisons — amounts are US dollars

Figure 26: Applying form, color and feel

ENSURING SUCCESSFUL MANUFACTURING IMPLEMENTATION

While you are optimizing the form, material and texture of a handheld device's grip, it's a good time to think about manufacturing.

Designing for manufacturability can help avoid costly setbacks and reduce development time. Understanding the processing needs for specific materials will help you to make design decisions that facilitate production and accelerate time to market.

It's important to follow best practices and refer to material processing guides, available from suppliers. The following best practices for overmolding a TPE material can help you improve processing success.

Top 10 Rules for Overmolded Components

1. Match the chemistry of the TPE to the substrate for optimized bonding
2. For new component designs, flow ratios (L/T) should be between 80:1 – 120:1
3. Incorporate air vents between 0.0005" and 0.001" along the perimeter and/or at the end of fill
4. Incorporate good flow shutoffs to prevent flashing
5. Add surface texture to prevent sticking and to mask aesthetic defects
6. Use a rigid substrate for easy ejection from the mold
7. Ensure the TPE layer is thick enough to ensure good bonding. Minimum thickness is typically 0.040". Or use mechanical interlocks if the layer is thinner.
8. The thickness of the substrate section should be twice that of the TPE section to minimize warpage
9. Use an appropriate gate size depending on the type and thickness of TPE. Start with a small gate.
10. A balanced runner system or hot runner in large cavitation parts is critical for balanced flow and good bonding

Process analysis is another useful capability for the manufacturing stage. Figure 27 represents a plastic injection molding process analysis simulation that allows for design, process settings, machine and tool recommendations. The image shows the result of a fill analysis that predicts the polymer flow in the mold. This is one of the common analyses used to verify the quality of the mold design and process.

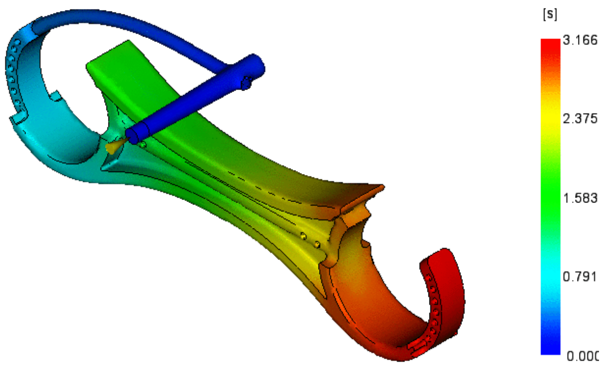


Figure 27: Mold flow fill analysis

ADDITIONAL RESOURCES

To learn more about using TPEs to enhance your products, visit the Avient TPE Knowledge Center to find resources including the comprehensive GLS™ TPEs Overmolding Guide and the TPE Injection Molding Guide.

HOW AVIENT CAN HELP

We can help you improve the ergonomic properties of your handheld device to achieve greater usability, comfort, safety and satisfaction.

Avient offers a comprehensive portfolio of specialized and sustainable materials to help you solve your toughest design and manufacturing challenges. Our design, engineering and technical services can support every step of your new product development process.

Contact us to learn how our teams can assist with selecting the right material type, color and texture; designing for improved ergonomics; providing engineering simulations to virtually prototype your design; optimizing material or manufacturing performance; and troubleshooting processing issues at the press.

1.844.4AVIENT (844.428.4368)
avient.com

AVIENT™