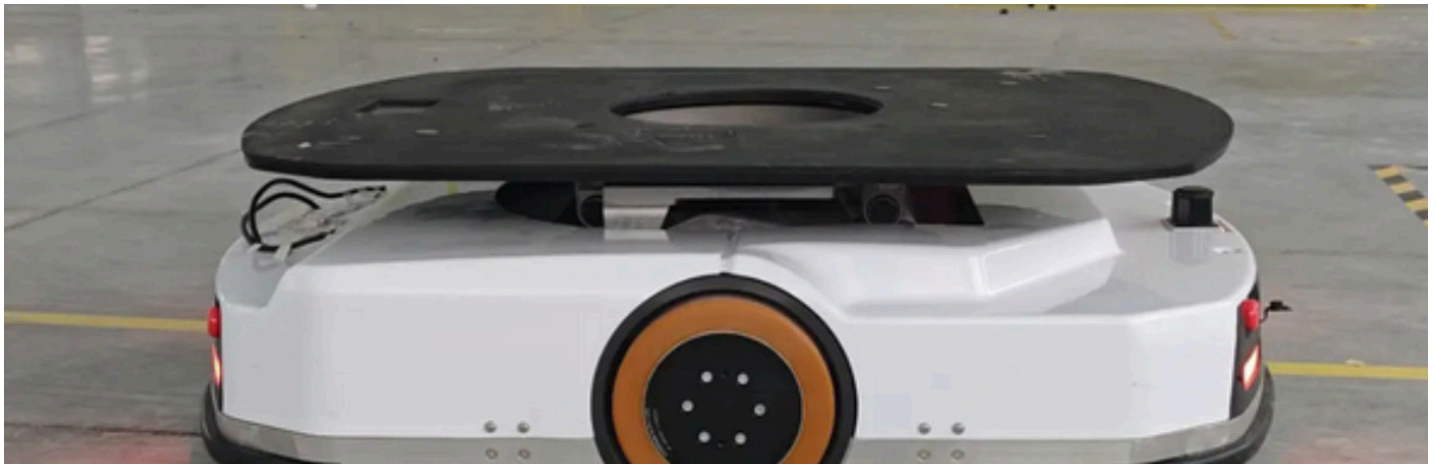


Custom Polyurethane Formulations in Robotics

When Standard Materials Fall Short in Performance-Critical Applications



— INTRODUCTION

Robotic and automation systems increasingly operate in narrow performance windows. Higher speeds, tighter tolerances, sensitive electronics, and demanding environments place conflicting requirements on components and materials. Engineers are often forced to balance wear resistance against compliance, cleanliness against durability, or conductivity against mechanical strength.

In many cases, off-the-shelf materials cannot meet these competing demands without compromise. When performance limitations appear late in development—or worse, after product launch—the result is costly redesign, delayed programs, and reduced system reliability.

This white paper explores why standard materials often fail in robotic applications, what custom polyurethane formulation actually enables, and when engineers should consider a tailored material solution.

Why Robotics Pushes Materials Beyond Standard Grades

Robotic systems differ from traditional industrial equipment in several important ways:

- High cycle counts with continuous dynamic loading
- Compact designs with limited space for overengineering
- Sensitive electronics exposed to vibration, shock, and static
- Environmental constraints such as cleanroom operation or chemical exposure

These conditions create competing material requirements. A component may need to be stiff enough to maintain accuracy, compliant enough to absorb energy, clean enough for contamination control, and durable enough to survive millions of cycles.

Standard materials are rarely designed for this level of specificity.

Limits of Off-the-Shelf Materials

Engineers often begin material selection with readily available options such as rubber, engineered plastics, or standard urethane grades. While these materials perform well in certain applications, they introduce tradeoffs in robotics.

RUBBER

- Good compliance and energy absorption
- Limited wear resistance under high load
- Poor dimensional stability over time

ENGINEERED PLASTICS

- Good stiffness and machinability
- Limited damping and shock absorption
- Susceptible to cracking, creep, or chemical attack

STANDARD URETHANE GRADES

- Broad performance ranges
- Designed to satisfy general use cases
- Often force compromises between wear, stiffness, and environment

When robotic systems push these materials outside their intended performance envelope, issues emerge as premature wear, inconsistent behavior, or failure to meet cleanliness or electrical requirements.

What “Custom Polyurethane Formulation” Actually Means

Custom polyurethane formulation is not simply choosing a different hardness. It is the deliberate tuning of material chemistry to achieve a specific balance of properties for a defined application.

Engineers can tailor:

- Durometer and modulus to balance stiffness and compliance
- Conductivity or static dissipation for ESD-sensitive systems
- Cleanliness and particulate behavior for controlled environments
- Wear behavior for rolling, sliding, or impact conditions
- Environmental resistance to chemicals, temperature, or washdown

Unlike surface treatments or coatings, these properties are engineered through the bulk material, ensuring consistent performance over the life of the component.

Formulation and Process Must Work Together

Material chemistry alone does not determine performance. In robotics, manufacturing and post-processing are just as critical.

Key considerations include:

- Molding methods that control density and internal stress
- Post-molding processes that influence surface finish and cleanliness
- Tight process control to ensure repeatability across production runs

Inconsistent processing can negate the benefits of a well-designed formulation. For performance-critical robotic components, formulation and process must be developed together.



Rapid Prototyping and NPI Timelines

Robotic product development timelines are often aggressive. Waiting months for material validation is rarely an option.

Custom formulation programs are most successful when paired with:

Rapid prototyping cycles

Iterative engineering
collaboration

Early validation under real
operating conditions

This approach allows engineers to converge on the correct material solution before designs are locked, reducing downstream risk and avoiding late-stage redesign.

— CASE SNAPSHOTS

High-Load Polyurethane Rollers

A robotics OEM required rollers capable of sustaining high loads without deformation or premature wear. Standard materials failed to meet durability requirements. A custom polyurethane formulation was developed to improve compressive strength and wear behavior while maintaining dimensional stability. The resulting rollers delivered extended service life and improved system reliability.

Cleanroom-Qualified Urethane Wheels

An automation OEM developing a cleanroom robotic system required urethane wheels that met ISO cleanliness standards while maintaining tight tolerances and durability. Through multiple rounds of rapid prototyping and formulation refinement, a custom conductive urethane and controlled manufacturing process were developed. The final solution met cleanliness requirements and supported a critical product launch timeline.



When Engineers Should Consider Going Custom

Custom polyurethane formulations are most appropriate when:

- Off-the-shelf materials force unacceptable tradeoffs
- Performance issues appear late in development
- Environmental or cleanliness requirements are critical
- Wear life or consistency limits system scalability
- Redesign risk outweighs upfront development effort

Engaging material expertise early allows performance requirements to drive the solution, rather than adapting designs to fit material limitations.

Conclusion

As robotic systems become faster, more compact, and more performance-driven, standard materials increasingly fall short. Custom polyurethane formulations allow engineers to align material behavior directly with application requirements rather than accepting compromise.

By combining tailored material chemistry with controlled manufacturing processes and rapid prototyping, engineers can solve complex performance challenges and deliver reliable, scalable robotic systems.

When standard materials no longer meet the demands of an application, custom formulation is often the most direct path to long-term success.

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