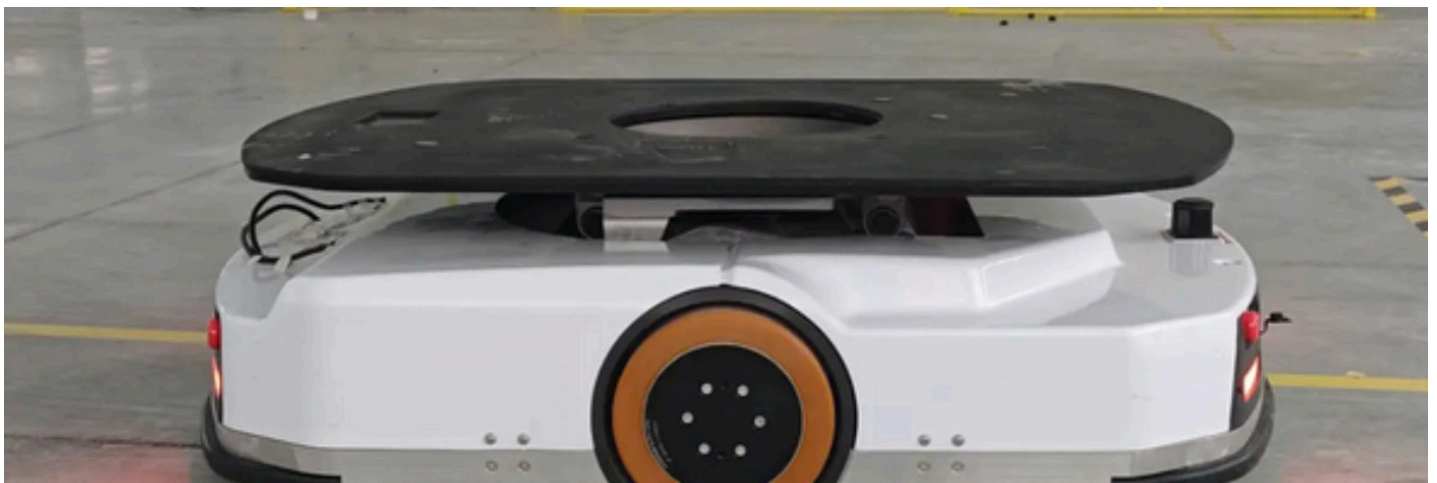


Engineering Urethane Wheels and Rollers for Robotics and Automation

How Engineers Design for Load, Wear, Traction, and Reliability in High-Duty Systems



— INTRODUCTION

Wheels and rollers are among the most critical — and most stressed — components in robotic and automation systems. Unlike traditional material handling equipment, robotics introduces higher speeds, frequent acceleration and deceleration, tighter motion control, and significantly higher cycle counts.

As a result, wheels and rollers that perform adequately in conveyors or legacy systems often fail prematurely when applied to robotics. Common issues include rapid wear, loss of traction, deformation under load, and inconsistent performance between identical systems.

This white paper examines why wheels and rollers fail in robotic applications, the key design variables engineers must balance, and why cast urethane has become the preferred material solution for demanding automation environments.

Why Wheels and Rollers Fail in Robotic Systems

Robotic duty cycles place unique demands on rolling components.

Common contributors to failure include:

- High-cycle motion with frequent starts, stops, and direction changes
- Side loading and misalignment from system tolerances
- Dynamic loading during acceleration and deceleration
- Compact designs that limit wheel size and contact area

In many cases, wheels and rollers are selected based on static load ratings or prior experience in non-robotic systems. While these criteria may appear sufficient on paper, they fail to capture the dynamic forces and wear mechanisms present in robotics.

Over time, these mismatches manifest as inconsistent traction, premature wear, vibration, and reduced system reliability.

Core Design Variables Engineers Must Balance

Successful wheel and roller design in robotics requires balancing multiple interdependent variables. Optimizing one in isolation often leads to failure elsewhere.

MATERIAL SELECTION AND DUROMETER

Durometer plays a central role in wheel and roller performance.

SOFTER

Softer materials improve traction and energy absorption but may deform excessively or wear faster under load.

HARDER

Harder materials improve wear resistance and reduce rolling resistance but can sacrifice grip and transmit vibration.

Selecting the correct durometer requires understanding load per wheel, speed, duty cycle, and floor interaction — not just wear life.

GEOMETRY AND LOAD DISTRIBUTION

Geometry determines how load is transferred through the wheel or roller.

Key considerations include:

- Contact patch size and shape
- Crown profiles and edge loading
- Deflection under operating load

Poor geometry can concentrate stress at the edges, leading to chunking, flat-spotting, and accelerated wear. Even with the correct material, improper geometry will shorten service life.



OPERATING ENVIRONMENT

Environmental conditions heavily influence performance.

Common robotic environments include:

- Warehouse floors with dust and debris
- Cleanroom or contamination-controlled spaces
- Exposure to cleaning chemicals or washdown

Materials and surface finishes that perform well in one environment may fail in another. Environmental factors must be considered early in the design process.

ELECTRICAL BEHAVIOR (WHEN REQUIRED)

In certain robotic applications, wheels and rollers must manage static charge.

Standard urethane formulations are electrically insulating and may allow static buildup, leading to particulate attraction or interference with sensitive electronics. In these cases, conductive or static-dissipative urethanes are required.

Electrical performance must be engineered through the bulk material to remain consistent over the life of the component.

Why Cast Urethane Is the Preferred Material

Cast urethane has become the material of choice for robotic wheels and rollers because it allows engineers to tune performance rather than accept compromise.

Compared to rubber and machined plastics, cast urethane offers:

Broad tunability of durometer and mechanical properties

Excellent wear resistance under rolling and sliding conditions

Controlled compliance for traction and vibration management

Bulk conductivity options for ESD-sensitive applications

Equally important, cast urethane enables material properties and geometry to be engineered together, resulting in predictable, repeatable performance.

The Role of Manufacturing and Post-Molding Processes

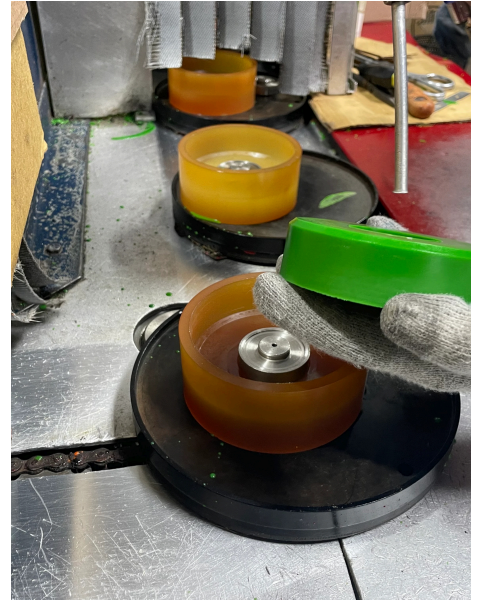
Material selection alone does not guarantee performance.

In robotic applications, manufacturing variables such as molding method, curing, and post-molding processes directly influence surface finish, dimensional stability, and cleanliness.

Tight control over these processes ensures:

- Consistent wheel-to-wheel performance
- Controlled surface roughness and friction behavior
- Dimensional repeatability across production runs

Without process control, even well-designed materials can underperform in the field.



CASE SNAPSHOTS

High-Load Polyurethane Rollers

A robotics OEM required rollers capable of supporting sustained heavy loads without deformation or premature wear. Standard materials failed to maintain dimensional stability under dynamic conditions. A cast urethane roller solution was engineered to optimize material formulation and geometry, resulting in extended wear life, reduced deformation, and improved system reliability.

Cleanroom-Qualified Urethane Wheels

An automation OEM developing a cleanroom robotic system required urethane wheels that met ISO cleanliness requirements while maintaining tight tolerances and durability. Through iterative prototyping and engineering collaboration, a custom conductive urethane formulation and controlled manufacturing process were developed. The final solution met cleanliness standards, delivered extended wear life, and supported a critical product launch timeline.

Design Guidance: When to Go Custom

Custom-engineered urethane wheels and rollers are most appropriate when:

- Off-the-shelf solutions fail to meet wear or load requirements
- Environmental or cleanliness constraints are critical
- Redesign risk outweighs upfront development effort
- Traction or consistency issues appear during validation
- Electrical behavior must be controlled

Engaging engineering expertise early allows performance requirements to drive design decisions rather than forcing compromises later.



Conclusion

Wheels and rollers play a central role in robotic system performance, reliability, and scalability. In robotics, failures are rarely caused by a single factor — they result from imbalances between material, geometry, environment, and duty cycle.

Cast urethane enables engineers to balance these variables and design rolling components that perform predictably under real operating conditions.

By addressing wheel and roller design early in the development process, engineers can avoid premature failures, reduce maintenance, and support long-term system success.

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