

Architecture, Comparison, and Application Guidance of Parallel Axis and Planetary Traction Wheel Drives for Electric Vehicles

Overview

Electric wheel drives for vehicles most commonly use two principal gear architectures: parallel axis and planetary gear drives. Each design offers distinct benefits in terms of efficiency, torque density, packaging, durability, and cost. Parallel axis drives are known for their efficiency, straightforward construction, and low cost, while planetary drives excel in torque density and are better suited for compact spaces. Both systems allow for the integration of power-off brakes, encoders, and connectors to support varied application requirements. Typical uses include outdoor power equipment, mobile robots, automated mobile robots (AMRs), automated guided vehicles (AGVs), automation systems, material handling equipment, medical mobility scooters, wheelchairs, walk-behind and ride-on floorcare machines, as well as man lifts.

Parallel Axis Wheel Drives



Architecture

Parallel axis drives transmit power using gears whose rotational axes are offset. In a single-stage setup, a driving pinion meshes with a driven gear. For multi-stage configurations, intermediate cluster gears are added to increase reduction ratios. This approach enables ratio scaling without needing gears with vastly different diameters.



Advantages

- Only one gear mesh per stage means rolling and sliding losses are minimized. Typical efficiencies range from 94 to 98%, making parallel axis drives ideal for electric vehicles where energy efficiency is critical.
- Simple gear geometry, ease of assembly, and lower engineering complexity reduce component count and development time.
- Standard gear manufacturing processes and simplified components help keep costs minimized.
- The offset axis allows encoders to be mounted on both input and output shafts, supporting safety standard compliance.

Limitations

- The offset shaft axis increases the overall width of the drive, which may challenge packaging within a wheel. However, the gearbox length remains relatively compact.
- Since torque is carried by a single gear mesh, stress per tooth is higher compared to planetary gear sets. Shock loading must be carefully considered during design.
- Achieving high gear ratios for high torque applications may require larger gears.

Planetary Wheel Drives



Architecture

Planetary wheel drives typically feature a driving sun gear and fixed ring gear aligned on the same axis. Between them, multiple planet gears are housed within a rotating carrier, sharing the torque load. Additional coaxial gear sets can be added to create multi-stage systems.



Advantages

- Multiple planet gears distribute torque, increasing capacity within a compact volume.
- The coaxial input and output arrangement is ideal for wheel hub applications with tight space constraints.
- Torque capacity can be enhanced by adding more planet gears or increasing the number of stages.

Limitations

- Multiple gear meshes per stage result in higher rolling and sliding losses, with efficiency typically ranging from 90 to 96%.
- Increased precision required for carrier and planet alignment.
- Complex processes required for manufacturing the ring gear's internal teeth result in higher production costs.
- Large bearings and greater number of parts and complex assembly drive up manufacturing and assembly costs.
- Dense layout, lack of space for lubricants, and proximity to the motor generate more heat.

Comparison

Torque vs Size

Increasing the torque capacity of parallel axis drives may require expanding both width and length, while for planetary drives, changes in length are typically sufficient.

Efficiency vs Power Density

Parallel axis drives are preferred for energy-sensitive vehicles, whereas planetary drives perform best in applications with strict space limitations.

Noise, Vibration, Harshness (NVH)

Both gear systems can achieve excellent NVH characteristics with appropriate design. Parallel axis drives have fewer gear meshes to adjust for NVH, while planetary drives naturally provide a smoother load distribution.

Thermal Behavior

Parallel axis drives offer easier cooling paths and lower heat density. Planetary drives concentrate heat more and may require advanced lubrication, such as oil circulation or dedicated cooling channels.

Application Guidance

Light Duty and Cost Sensitive Vehicles

Parallel axis drives are preferred for their lower cost, high efficiency, and sufficient torque capacity.

Wheel Hub Drives

Planetary drives are favored due to their coaxial design, compact packaging, and ability to deliver high torque in limited spaces.

Autonomous and Robotic Vehicles

Both drive types are suitable; parallel axis drives are preferable when efficiency or cost is a priority, while planetary drives should be chosen when power density is more important.

Conclusion

Parallel axis and planetary wheel drives each offer distinct advantages depending on application requirements. Parallel axis drives are ideal for light duty and cost-sensitive vehicles due to their lower cost, high efficiency, and sufficient torque capacity. They also feature superior cooling paths and reduced heat density, making them simpler to manage thermally. On the other hand, planetary drives excel in wheel hub applications, as their coaxial design, compact packaging,

and high torque delivery are well-suited for limited spaces.

In autonomous and robotic vehicles, the selection depends on priorities. Parallel axis drives should be chosen when efficiency or cost is paramount, while planetary drives are preferable for high power density needs. Ultimately, the choice between parallel axis and planetary drives hinges on the demands of the vehicle and the operational environment.

EXPERIENCE BETTER PRODUCTS FOR BETTER GROWTH

Based in Pennsylvania, USA, ASI Drives has earned a reputation as one of the most reliable manufacturers of custom gear drives. We've designed, engineered, and assembled the solutions that have helped drive businesses forward — and we can do the same for yours.

GET IN TOUCH TO LEARN MORE.



215-661-1002



sales@asidrives.com

www.asidrives.com

