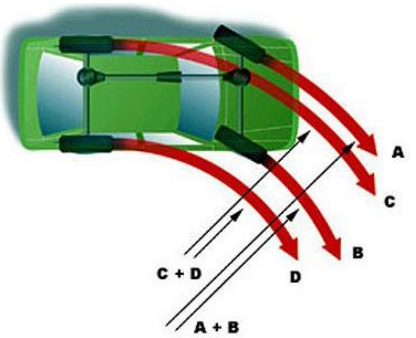
The causes of driveline windup



The sum of the rpm of front wheels (A+B) is higher than the combined rpm of the rear wheels (C+D).

When a car corners, all four wheels rotate at different rates since each follows a different imaginary circle. The two wheels on the inside of the turn rotate slower than the pair on the outside, for they follow a smaller radius circle. The front wheels must rotate faster than the rear ones, for they follow a larger radius circle.

For best traction *both* front and rear wheels ideally should propel the vehicle. Therefore a differential or transaxle (a combined transmission and differential) is required, to allow differing rotational speeds.

Without a differential either the inner wheel rotates too fast or the outer wheel drags, which results in difficult and unpredictable handling, damage to tyres and strain on, or possible failure of, the entire drivetrain. The differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn.

An **H-drive** drivetrain is used for heavy off-road vehicles to supply power to each wheel. H-drives do not use axles but rather individual wheel stations. With a permanent 4x4 drive there is no 'diff' action between the front wheels and rear wheels on either side. Normally on a two wheel drive, a centrally-placed differential on the driving axle allows the outer drive wheel, through the geared half-shafts) to rotate faster than the inner drive wheel during a turn. This is the **drawback to the H-drive design**. All four driving wheels therefore must have an opportunity to be momentarily raised off the ground to allow them to slip and take off any windup tension. Of course, off-road work - for which the Ferret is designed - allows this to happen. The varying track radii (shown above) mean that in a vehicle driving in a curve on firm tarmac each wheel travels a different distance. Since there is no differential action between the wheels on each side of an H-drivetrain four-wheel drive, this causes wind-up in the bevels and shafts.

Travelling on hard metalled roads - motorways and dual carriageways – particularly at speed, will cause windup. This will not happen so readily on smaller A- and B-roads. You used to be put on a charge if a Ferret was driven over 40 mph. Windup is exacerbated when components heat up through speed. A permanent non-changing load will make this worse. The Ferret is designed to be driven laden. Take corners gently and reduce speed. Sharp cornering will make wheel looseness worse. Normal driving does not present a problem.

It is also important that tyres are matched. Four-wheel drive vehicles with unmatched tyres will also suffer from windup, with consequent binding and wear of the drivetrain. The Ferret manual states that each the circumference of each pair of tyres should be within 2" tolerance. Run a tape measure around them and inflate them all to the same size. Also make sure that the air pressures in them are maintained, as a relatively small variation can have a fair impact on tyre size. If you can't get the tyres all to the same size, pair them on the same side of the vehicle, as the differential will take care of side to side variation. It also helps if all the tyres are of the same type.

Torque from windup at the outside of the wheel is about 200 lb/foot*, but at the centre, where the bolts and dowels hold the wheel, it is 4,000 lb/foot. Once the damage is done, the dowels will loosen a couple of thousandths of an inch and wear loose with uncureable play, rather like re-assembling Ikea furniture. Locktight will hold to a torque of about 45 lb/foot, but replacing dowels and retightening the bolts and dowels only works so far. A new wheel station has to be fitted, and the old ones re-machined to take slightly larger, oversized, dowels.

The first indication of loosening wheels is leaking of EP 90 gear oil down the inside of the tyre walls. The front wheels tend to go more than the rear wheels, possibly due to having less weight or because they are the steering wheels. With no windup, a Ferret can be pushed by two people. With half lock they can push 8 inches. After that, 10 people won't push it any more. Windup acts like a brake. If the wheels on one side are jacked up with windup present, you'll see the tyres rotate 4-6 inches. Two – three inches slip on the road translates to a fraction of a degree at the centre of the wheel.

- The **pound-foot** is a traditional English unit of **torque**. The angular equivalent of linear force, torque is the tendency of a force to produce a rotation. Torque is the product of the force and the distance from the centre of rotation to the point where the force is applied. The SI equivalent of the pound-foot is, naturally enough, the **Newton meter (Nm).** The **foot-pound** is a traditional English unit of **work.** It is equal to the work done by one pound of force acting through a distance of one foot. For example, when James Watt determined that a horse could lift 550 lbs. at a rate of one foot per second (33,000 ft lb/min) he declared it one horsepower (= 746 Watts of electrical power). The SI equivalent of the foot-pound is the **Joule.**