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RDF shredder: Hydraulic direct drive or mechanical drive?

Refuse-derived fuel (RDF), a substitute fuel for cement and lime plants, is processed in shredders, a technology that transforms bulky wastes to a particle size of 80mm or less. As the material being processed is not homogeneous, shredding produces a considerable number of shocks in the system. The shocks are critical to the shredder, specifically the rotors and consequently the rotor drives. So... what kind of drive is best at handling this kind of application?

Imagine driving your car at 100km/hr (60mph), slamming on the brakes, then immediately going 100km/hr backwards. That is what happens in shredding when the rotors with knives jam. The shock forces pass through the whole system. A mechanical gearbox suffers the most from such forces, with overloaded gearbox internals damaged prematurely.

Some manufacturers state that they have the solution to the above issue. Indeed, a hydraulic direct drive, avoiding the gearbox altogether, is often presented as the answer to handling the shockloads. It also provides high torque levels, essential for processing waste. They seem to be the best choice.

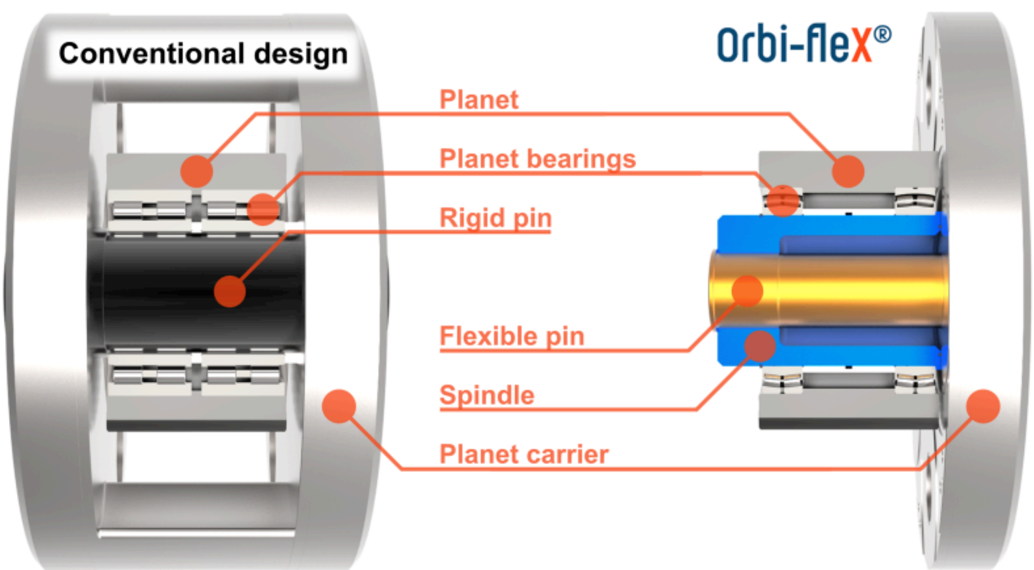
However, are these the only aspects to be considered? What if, instead, there was a shockload-resistant gearbox that had no risk of limited drive life, no requirement for excessive maintenance and, at the same time, a high torque density in a compact housing that addresses the space issues, especially of mobile versions of shredders?

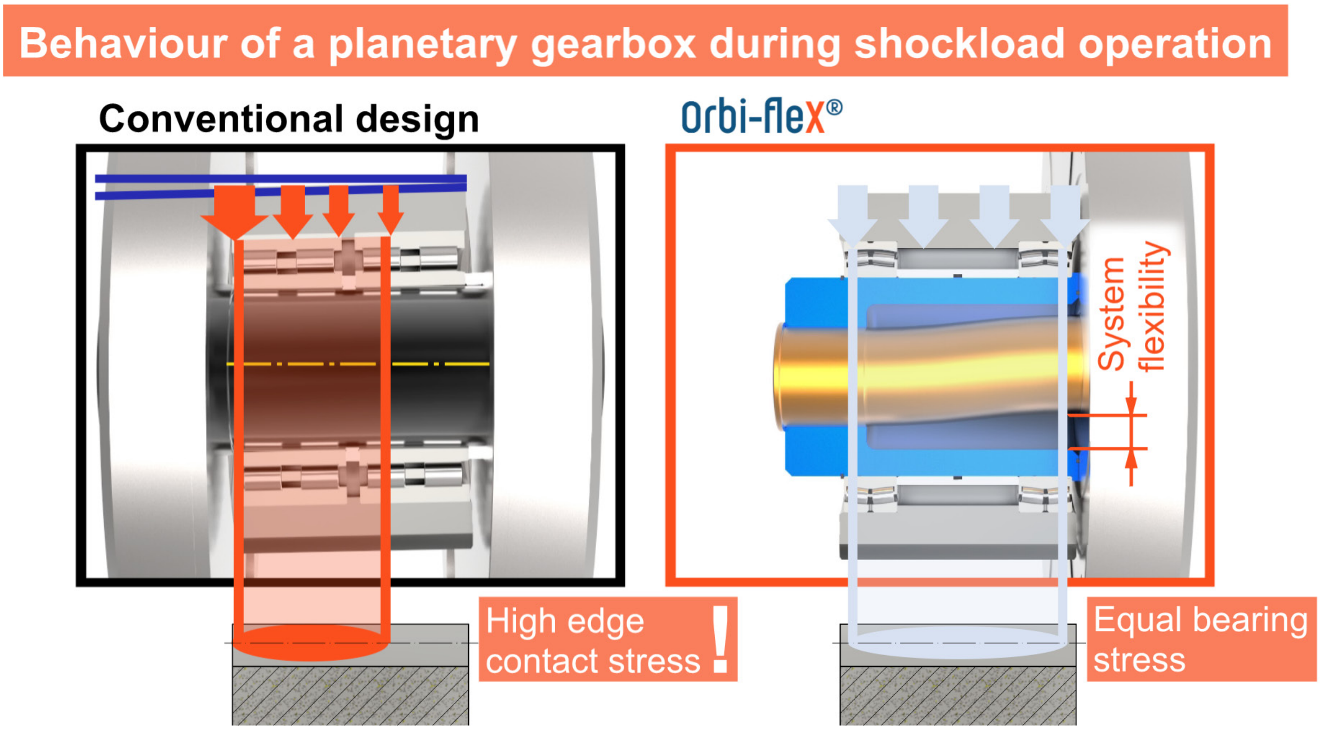
What is the right answer to the complex shredding challenges?

In planetary gearboxes shockload resistance can be handled through compound cantilever flexible planet pins. These flexible pins were invented by Ray Hicks in the 1960s. The principle is that the planet of the gearbox is released to move in a controlled manner and always stays parallel. This ensures perfect load distribution on the bearings. At the same time, the contact pattern of the gear tooth goes across its whole width, which eliminates pitting.

This is in contrast to the behaviour of a conventional planetary gearbox during a shock load, when the structure of the conventional design tends to deform and thus forces planets to tilt from their ideal positions. As a result, contact pattern between teeth is moved to one side of the gearing. This causes tooth overloading and unequal bearing load

Right: Comparison of two designs of a planetary gearbox. Conventional solution with a rigid pin (left) and shockload resistant Orbi-fleX with flexible pin (right).





Above: Critical narrow tooth contact pattern during shockload (left) versus parallel motion and perfect load distribution through flexible pin of the shockload resistant Orbi-fleX gearbox (right).

distribution leading to gear and bearing damage. This is why many shredder manufacturers avoid planetary gearboxes. However, a planetary gearbox with flexible pins does not suffer such damage and is therefore ideal for shock load applications.

Reduced maintenance and lifetime costs

Hydraulic systems use fluids to transfer energy from one location to another. Fluids have a major advantage over solids in that they can be easily transferred via hoses. Hydraulic systems generally suffer less damage than other systems because there are fewer hard surfaces rubbing together. In this respect they 'win' over conventional mechanical solutions.

However, hydraulic systems also have disadvantages. A hydraulic direct drive uses hydraulic hoses. These are sensitive to violent events, such as shock loads from shredding. Violent events can cause instant pressure spikes from 48bar to 344bar (700psi to 5000psi) within 0.1s. At the same time, the hydraulic hoses going to the pump from the motor can swell up, acting like a hydraulic accumulator. This swelling action can be detrimental if the replenishing system cannot make up for the instant loss of oil, as much as 100 gpm in a 0.1s period. The total volume lost is rather small, but the instantaneous loss is substantial. Due to their ability to respond rapidly, bladder type accumulators often are added to the system to aid replenishment, depending on hose length. Designers have to take this accumulator effect into account for all types of hydrostatic transmissions during the initial design phase. Shorter hose lengths are best, but not always possible.

Aeration is also a common issue. Hydraulic systems can develop loud banging noises, which result from air entering the hydraulic fluids. This banging noise results from the hydraulic fluids compressing and decompressing. This dynamic can also cause foaming, erratic actuator movements, degradation of the hydraulic fluid and damage to the internal parts of the hydraulic system. Users must filter oils in hydraulic systems on a regular basis to ensure that the hydraulic fluid contains no broken particles, as well as to eliminate damaging air pockets. These issues can be addressed these days, but they increase the price of the device.

A planetary gearbox seems to be cost efficient from the perspective of consumables. It does not require hydraulic hoses and fittings, hydraulic accumulators and frequent inspections and maintenance work that have to be calculated to the lifecycle of a final product. The advantage of a planetary gear unit is, however, valid only if the gearbox does not fail. This is a common experience from many typical shockload applications.

Gearboxes with flexible pin technology represent a very good choice. Their first installations were for wind turbines in Europe, an application where gearboxes must resist harsh irregular shockloads while the gearbox must be compact and lightweight. In this application checks of the gearbox internals after 10 years of operation showed no marks of excessive wear or even damage. This led Wikov to use the technology for other applications outside renewable energy. The flexible pin planetary gearboxes were fitted in mobile shredders in 2015 and their users confirm trouble-free operation.

Hydrostatic drive

Advantages

1. Good at handling shock load resistance.

2. Lower moment of inertia. (Can change speed quickly).

3. Fewer mechanical parts prone to wear.

4. Lower noise level.

Disadvantages

1. Lower efficiency (85-95%) = higher operational costs.

2. Initial costs 2-3 times higher than mechanical drive.

3. High consumable costs: hydraulic oil, filters, hydraulic hoses, fittings, seals.

4. Low pump life expectancy, mainly due to cavitation problems. Therefore intensive preventative maintenance is required.

5. Prone to fluid leaks and consequent fire risk in hot climates.

6. Hydraulic line bursts from cavitation, resulting in the destruction of the pump and/or motor.

7. Sensitivity to contamination of the working fluid and the need for a sufficiently high maintenance culture.

Shock load resistant gearbox

Advantages

1. Good at handling shock load resistance.

2. Higher efficiency (>97%) = Lower operational costs.

3. Reduced wear of gears and bearings.

4. Minimal maintenance costs.

Disadvantages

1. Higher moment of inertia = slower reaction during stops and start ups.

2. Consumables: gear oil, filters of the lubrication unit, seal.

3. Higher noise level.

4. Package requirements: mechanical connection does not allow same freedom as the hoses used in hydraulic drives.

Fuel and power savings

Should economy of the drive be an argument, a closer look into efficiency and power consumption will speak for itself. An average efficiency difference between hydraulic direct drive for shredders and a planetary gearbox is 6% in favour of gearboxes. This is an extremely significant figure. Considering operation time of a shredder of some 300 days/yr, 12hr a day, the savings achieved with a planetary gearbox driven by a diesel engine exceed Euro17,256/yr at a diesel price of Euro1.35/L (in Europe). Speaking about electrically-operated shredders with the same deployment regime and an electricity price of Euro0.08/kWh users can save Euro3456/yr. Owing to the high efficiency of a planetary gearbox, the mechanical solution becomes very justifiable.

Compact size saves valuable space

The size of a drive unit is often important. A hydraulic drive fitted to a rotor is obviously the most space-efficient solution. A planetary gearbox on the other hand is much larger. A planetary gearbox for shredders does not require any external lubrication system, nor heating unless operated in extreme conditions. This is in contrast to the hydraulic system, which demands space for fluid circulation. This can turn out to be more demanding overall on space demands than a gearbox.

There is no definite answer regarding which system is better. The view of what is 'better' may differ from user to user. It depends on individual circumstances and user preferences. The purpose of this article is to put both solutions on the scale and gain pros and cons of both shock resistant systems.