Saving space

Planetary gears pack a lot of torque in a small package, making them a natural for today's rotary machine axes.

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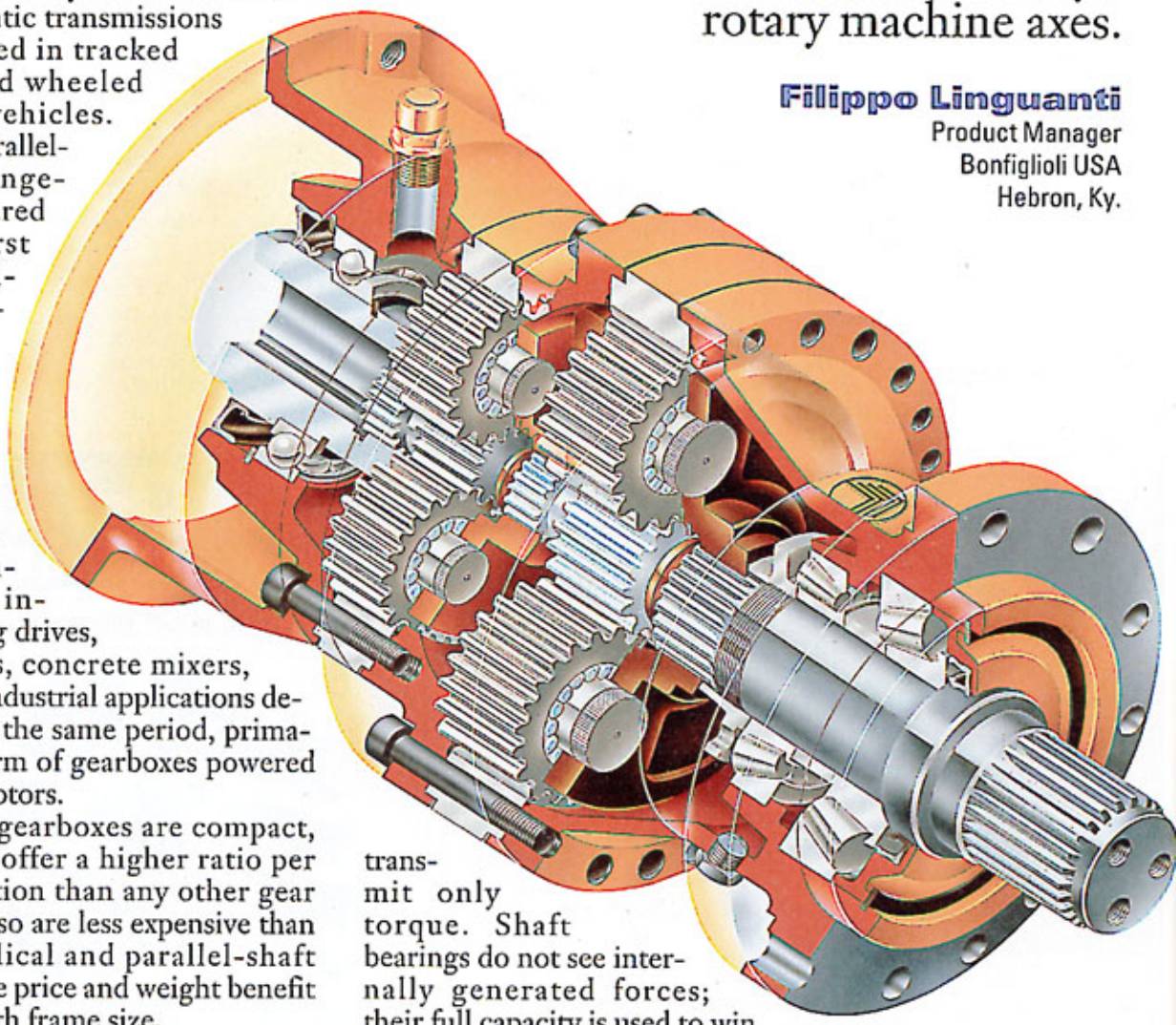
Planetary gears debuted in the early 1970s in automatic transmissions used in tracked and wheeled off-road vehicles. Planetary/parallel-shaft arrangements appeared in the first wave, followed by all-planetary travel drives. Eventually, planetary technology split off into today's common forms, including swing drives, winch drives, concrete mixers, and others. Industrial applications developed over the same period, primarily in the form of gearboxes powered by electric motors.



Planetary gearboxes are compact, rugged, and offer a higher ratio per single reduction than any other gear type. They also are less expensive than standard helical and parallel-shaft units, with the price and weight benefit increasing with frame size.

Super symmetry

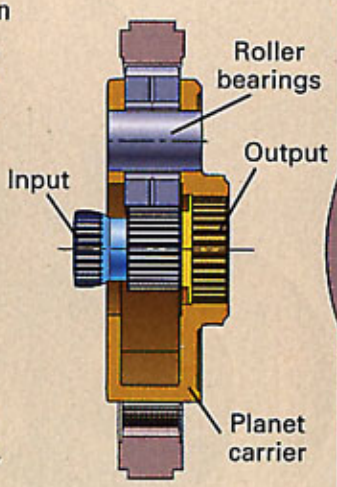
The symmetrical structure of planetary gearing, with planet gears 120° apart, generates a balanced system of forces. As a result, the gear train is self-aligning and the sun pinion is not to be born by any bearing. With forces in balance, the gears and planet carrier transmit only torque. Shaft bearings do not see internally generated forces; their full capacity is used to win the forces applied to the output shaft. It doesn't matter what angle the forces make with the shaft.

Another inherent advantage is that, at any instant, the load is shared by three teeth instead of one, as is the case in parallel-shaft gears. This, along with the self-aligning properties, ensures uniform distribution of the load among

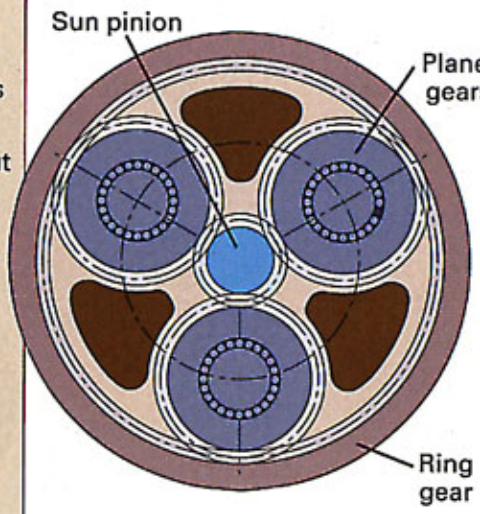
HOW THEY WORK

In a planetary gear, the sun pinion is the main drive element, connecting to the prime mover, an electric or hydraulic motor. The pinion meshes with (generally) three planet gears which, in turn, also mesh with an external ring gear. In industrial applications, the ring gear is static, fixed to the framework through a foot or flange mount.

Planet gears, sometimes called satellite gears, mount on rollers, which are part of the planet carrier. Roller or needle bearings are often used. The planet carrier connects to the output shaft or, in multiple stage units, to the sun pinion of the next reduction stage. Double, triple, and quadruple reductions are common.



Basic components



Planetary gearsets typically consist of a sun pinion that meshes with three planet gears, each of which mesh with an external ring gear. The planet gears are contained in a carrier, which connects to the output shaft or the pinion of another reduction stage.

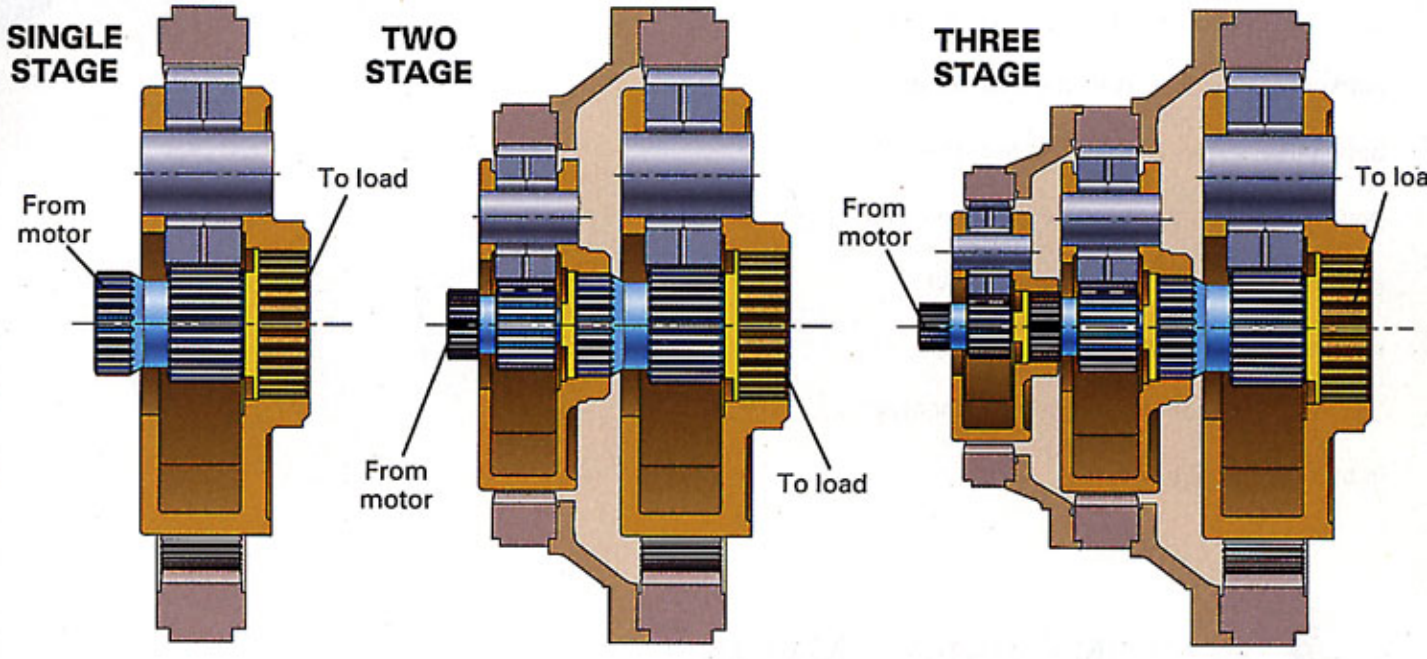
the gears and makes planetary drives more suitable against shock loading than equivalent parallel-shaft gearboxes.

Planetary drives also feature a greater number of elements sharing the torque which, at a parity of working stress, allows each of the gears to be designed smaller than equivalent helicals. This makes for a compact package, translating to lower peripheral speeds and fewer gear modules. The result: Planetaries are extraordinarily quiet and efficient.

Application considerations

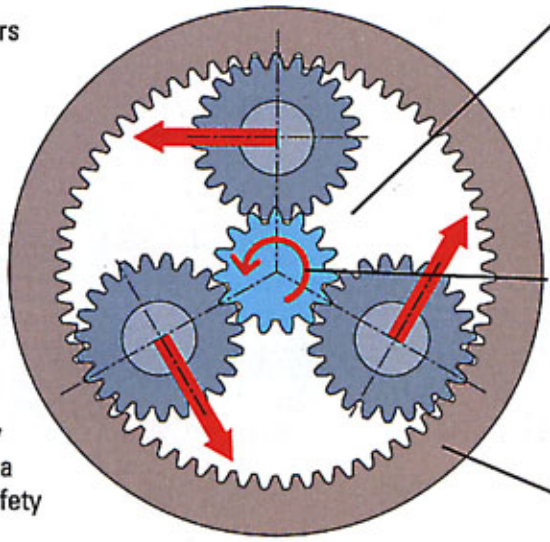
As with any rotary motion device, continuous operating

Multi-stage reductions



Planetary gears may be configured in two, three, and even four-stage reductions, using spline shafts to save space and weight. Spline connections also provide additional safety and isolation from forces generated externally.

Turn style



torque and speed are mandatory among the application data. In case of intermittent duty and variable torque output, it may be required to instead specify the load pattern (torque and operating speed per each time period of the work cycle) so that an equivalent torque can be calculated to select the optimum gear unit.

In both cases, the service factor S.F. must be taken into account based on the required daily operating time and duty (light, medium, or heavy). Service factors typically range between 1.0 and 3.0.

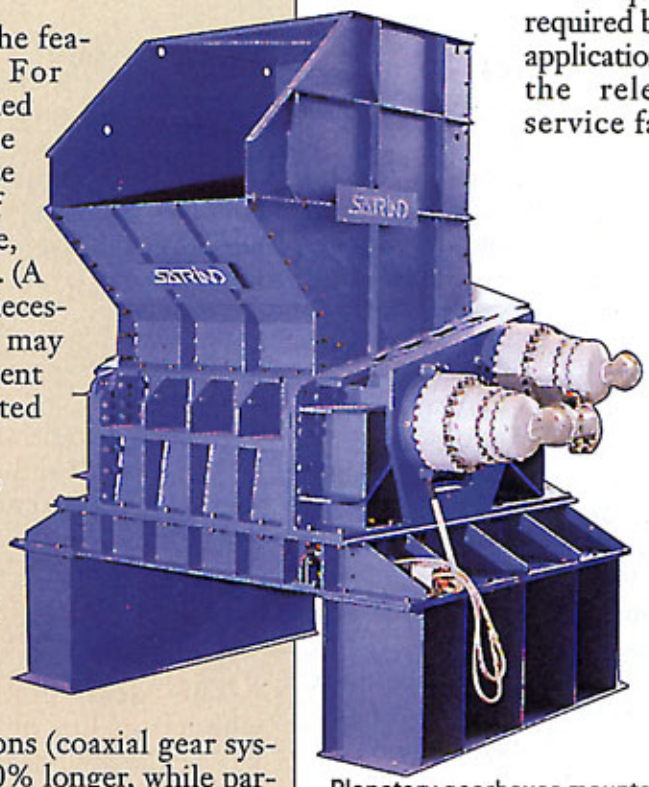
Given an application, the torque rating T_{n2} of the suitable gearbox is calculated from the torque T_{r2} required by the application and the relevant service factor

SHREDDING MACHINE

Shredding machines exemplify many of the features that differentiate planetary gears. For starters, the centers of the cutters are positioned in close proximity to each other to minimize space and cost. Such a design reduces blade size as well as the torque and peripheral speed of the cutting edges. The design is only possible, however, if the gear units are radially compact. (A reduced axial dimension, though not strictly necessary, is beneficial in terms of space.) Weight may also be a concern because of the bending moment due to the heavy mass offset and concentrated onto the bolting area.

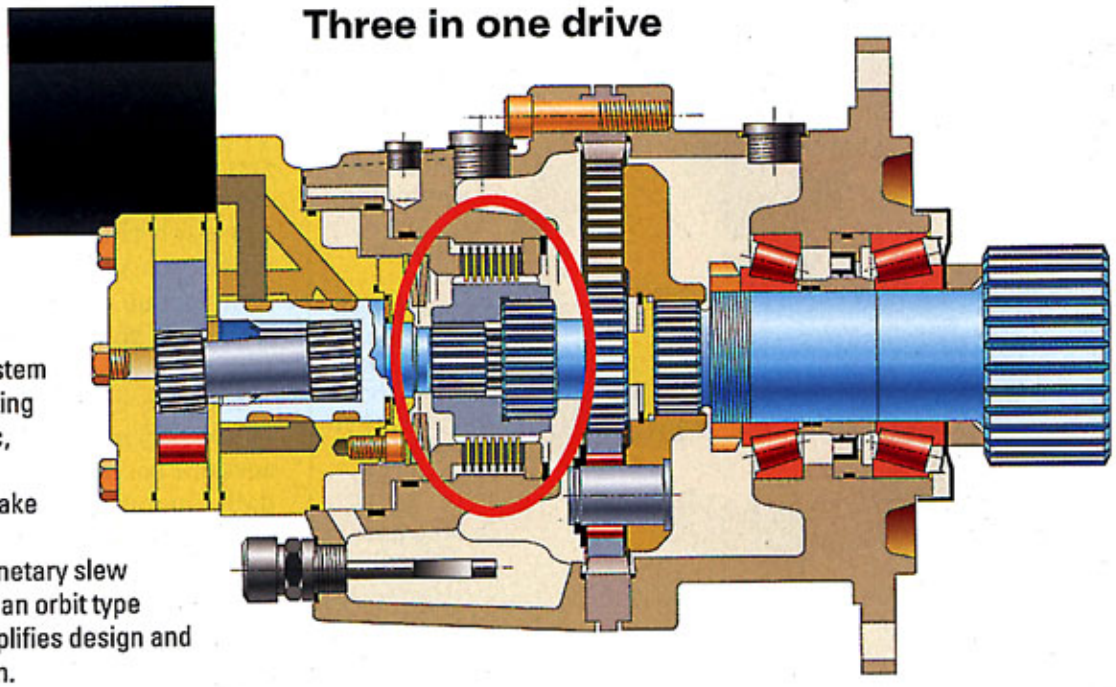
Gears for shredders, besides being compact, must also be rugged. Shredding machines operate in some of the harshest environments and with severe duty. The ability to withstand shock loads is a must not only for the gearing but also for the connections between shafts and gear cells.

All these features, of course, are inherent in planetary speed reducers. Alternative solutions (coaxial gear systems, for example) would be approximately 50% longer, while parallel shaft units would weigh twice as much. The momentary loading capacity of planetaries cannot be met by any alternative, nor can the possibility of a hollow splined shaft. This latter option ensures perfect shaft alignment, reduces machining costs of mating parts, and prevents fretting corrosion from seizing the shafts after long periods of operation.



Planetary gearboxes mounted in close proximity drive the cutters on this industrial shredder. Planetaries are ideal for such applications because of their compact size and rugged construction.

Three in one drive



A drive system incorporating a multidisc, failsafe parking brake (circled in red), a planetary slew drive, and an orbit type motor simplifies design and installation.

INTEGRATE IT

Industrial planetary gearboxes are often modular in nature with numerous options on both the output and motor side. Most interesting is their ability to be driven by either hydraulic or electric motors. In both cases a failsafe brake can be applied, either as part of the gearbox or as part of the motor. Obviously, in locations where ac current is not available, e.g. on board a vehicle, the hydraulic prime mover will tend to be preferred, with the electric motor being more widely used in traditional industrial applications.

A practical advantage of the modular structure is that the input section of the gearbox may be replaced at a later time and even retrofitted in the field if circumstances require. There's also flexibility in terms of drive options. Motor adapters, for example, can accommodate NEMA as well as IEC inputs.

S.F. for the same:

$$T_{n2} = T_{r2} \times S.F.$$

Torque demand T_{r2} (lb-in.) and speed n_2 (rpm) must be converted into horsepower P_{r2} (hp) as follows:

$$P_{r2} = \frac{T_{r2} \times n_2}{63{,}025}$$

Once that is known, the motor rating P (hp) can be calculated taking the efficiency EFF into account:

$$P = \frac{P_{r2}}{EFF}$$

The gear configuration, whether in-line or right angle, will be dictated mostly by space considerations with the machine layout suggesting which foot or flange mount is most appropriate. Shaft mounting is also possible, recommended even, for space reasons and the inherent self-alignment of the shafts. In this case, a torque arm will be necessary. For foot mounting, the main concern is shaft alignment. Any misalignment will overload the shaft bearings and reduce lifetime.

One thing to remember with regard to installation is that input and output shafts (on planetaries) always rotate in the same direction, regardless of the number of reductions. Also note that planetary gearboxes operate equally well in both directions, and efficiency is not affected by rotation direction. **MSD**

Planetary advantages

- Physically compact
- Light weight
- Low inertia
- Overhung load capacity
- Heavy duty impact/shock loading
- Low cost

For more information, call Bonfiglioli USA at (859) 334-3333 or visit www.bonfiglioliusa.com.