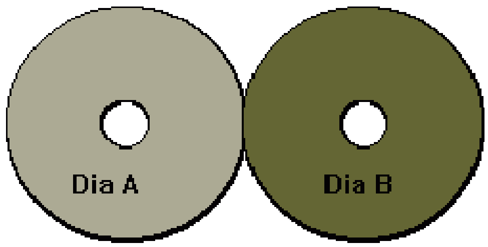
Epicyclic Gearing - An Overview

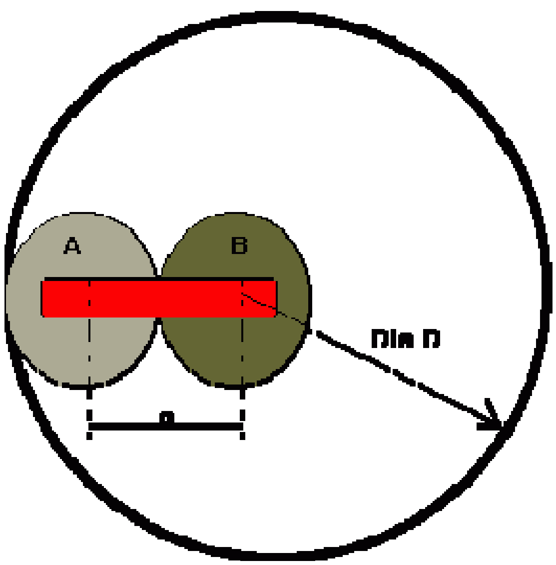
Excerpt from: www.marineengineering.org.uk

Principles of operation



If dia 'A' = dia 'B' then for one rotation of 'A' a point on the surface of 'A' would move through a distance equal to 2 x Pi x Ra; the distance that would be traveled by a point on 'B' would be 2 x Pi x Rb and as Ra=Rb. the ratio is 1:1.

One rotation of 'A' causes one rotation of 'B'



If the gear 'A' is fixed and 'B' allowed to rotate freely around it constrained within an annulus; then for one rotation of 'A' and corresponding rotation of 'B' the point of contact on the annulus would have moved through a distance equal to 2x P x Ra.
The circumference of the annulus would be equal to 2 x P x (Ra + Rb), hence for one revolution of 'A' then 'B' would have only traveled half way round the annulus.

By varying the size of the sun and planets the gear ratio can be altered. The outlet drive could be taken either off the bar 'c' or if 'c' was fixed off the rotating annulus.

Comparison of Epicyclic gearing to Tandem gearing

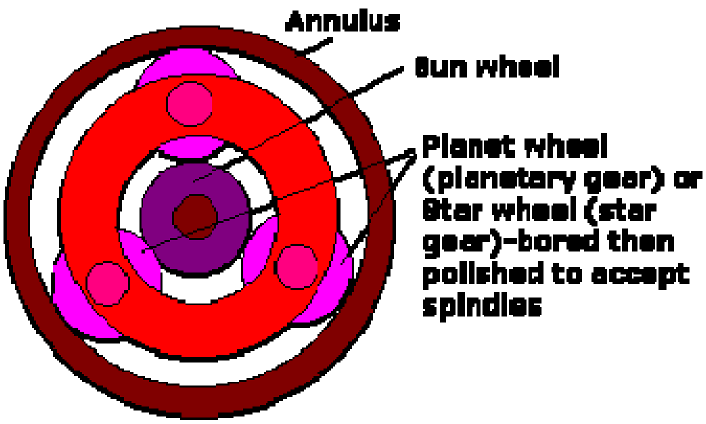
Advantages

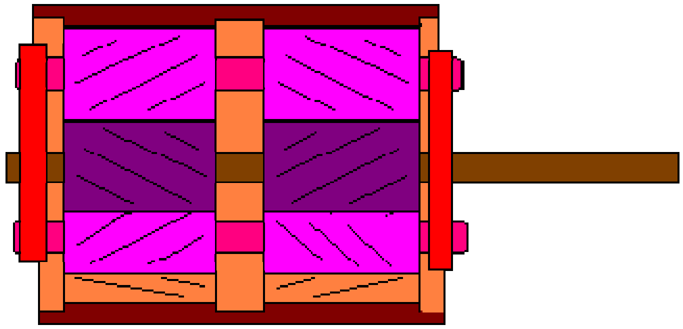
- The output may be reversed to requirement
- Small size and weight for given ratio (approx. 5% of wheel/pinion)
- Output same direction as input for planetary (ratios of 3-12:1)
- Output opposite direction to input for star (2-11:1)
- Co-axial input/output
- Initial cost may be slightly lower
- Slightly improved efficiency
- Operating cost lower
- Lower plant height

Disadvantages

- Requires very accurate alignment
- relatively high tooth load
- increased number of rotating parts
- Inspection and maintenance more difficult
- Increased meshing frequency means higher grade materials required

Types





The Star annulus has teeth on the inner rim. A resilient mount is provided when the star annulus is fixed. This allows a certain degree of distortion to occur reducing tooth loading. The planet wheels are located by a planet carrier ring, on fitted at each end

The system may be constructed in three different ways:

- Planetary- The star annulus is fixed. Input is via the sun wheel and out put through the plant wheel carrier ring
- Star-The planet wheel carrier is fixed. Input is via the sun wheel and output through the star annulus- This system is often seen as the first stage of turbine reduction gearing due to the possibility of high centrifugal stresses distorting the plant carrier ring and causing tooth overloading
- Solar- The sun wheel is fixed. This system is seldom used except in back to back epicyclic' s

The fixed member is called the torque reaction member. The number of wheels is determined by tooth loading

Epicyclic gearing alignment

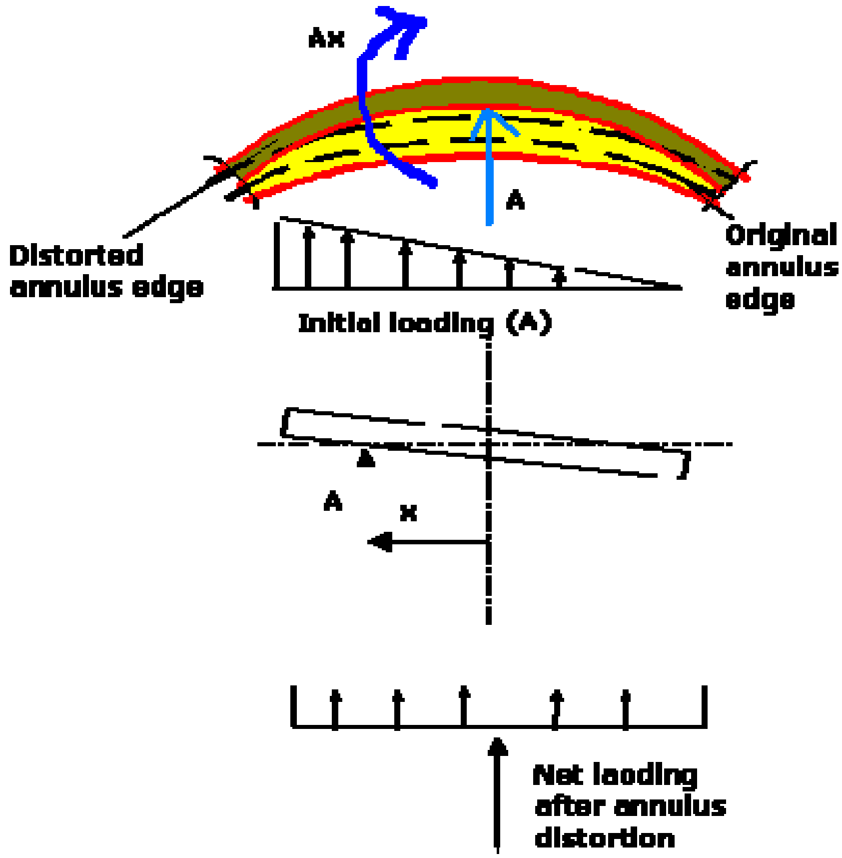
In normal operation epicyclic gear designs the planet pins are straddle mounted on a rigid carrier and are precisely aligned to each other.

If they are not the load distribution across the face is affected, but not the load sharing.

The sun pinion and flexible annulus are centered by the planet wheels when under load

With the ideally supported annulus, load sharing between the planets is ensured by the radial flexibility and uniform loading across the teeth by the self correcting toroidal twisting of the annulus and by the high accuracy of the gearing.

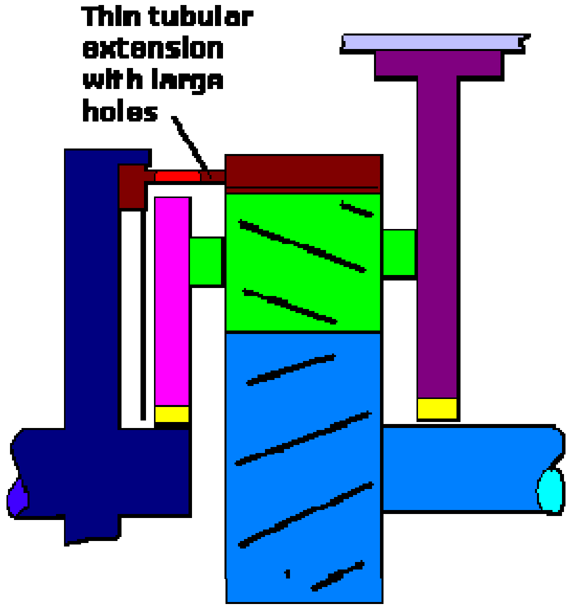
Toroidal twisting of annulus



The effect on tooth loading depends of on the supporting method of the annulus.

Introduction of Annulus flexibility

MAAG star gear



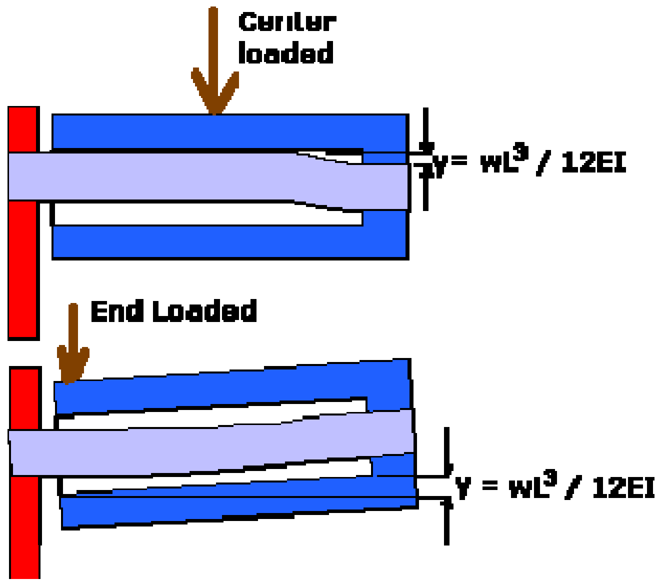
Toroidal twisting effect on the annulus is reduced to a minim by having the tubular extension thin, and nearly in line with the axial thrust from the teeth.

Other designs include the Allen-Stoeckicht where the split annulus of a double epicyclic gear are given a degree of movement within the carrier fo the two rings, this carrier itself is given a degree of axial movement by being fixed to the outer casing by a straight cut tooth coupling.

Also the Renk design has the annulus supported by a series of leaf sleeve spring packs. The annulus is split into two separate annuli. This design permits both torsional and radial movement and to a lesser degree angular movement in the diametrical plane. All movement is dampened by the oil and friction within the spring packs.

Introduction of flexible pin

Plane wheel spindle (vickers)



For this design the annulus is made radially stiff.

Tooth Design

Standard involute double helical tooth arrangements are used.

The planet/annulus centre and pressure angles are standard

Changing the diameter of the base circle within the tooth height does not effect the gear ratio. However, matching the root circle to the base circle makes the tooth all addendum and hence all the tooth is on the involute curve and no undercutting exists. This is especially used for the highly loaded teeth of the sun wheel.

The sun/planet ring used slightly increased diameters so as much as the tooth depth is used as possible.

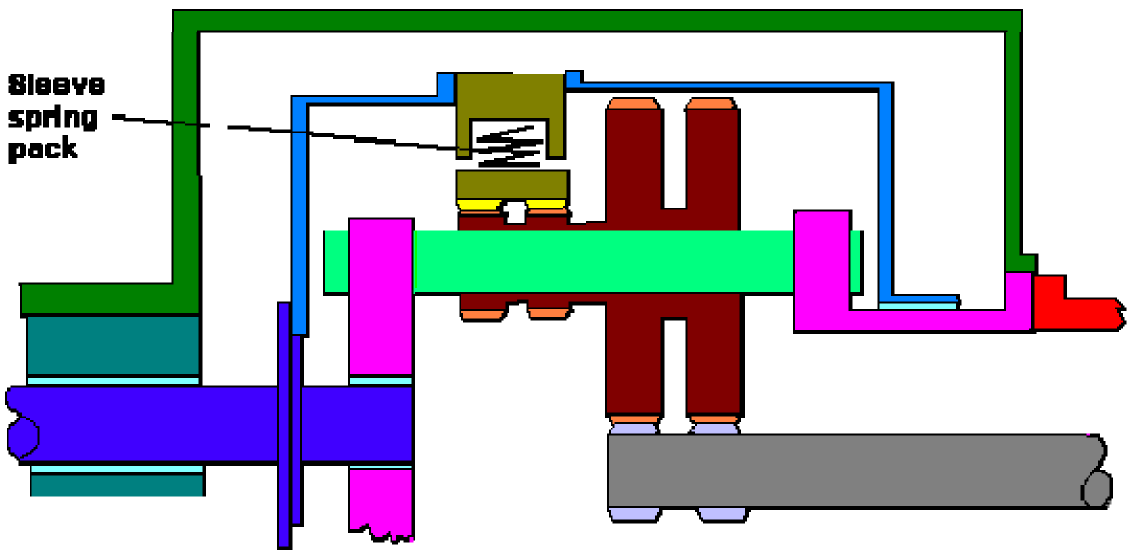
Carrier ring

Nearly always in the form of a short hollow cylinder. Having the following advantages;

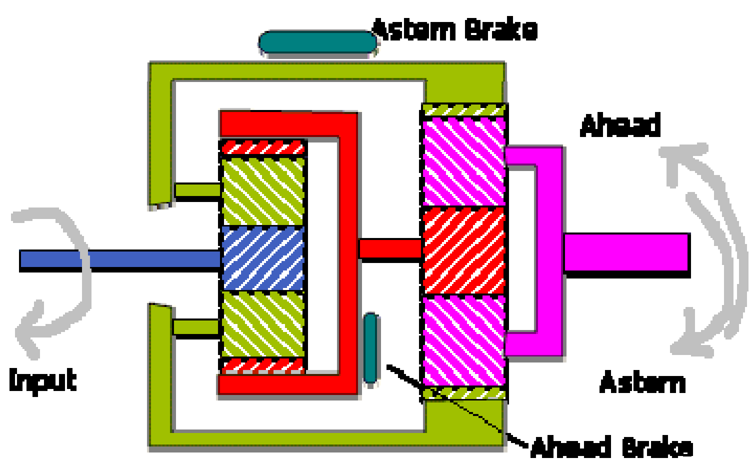
- ease and economy of manufacture
- strength and stiffness
- concentricity and potentially good balance

Renk Compound Gear

Offers 17-1 reduction capacity. The sleeve pack is adjustable to give the required torsional characteristics. The springs also give some bending flexibility and dampening through oil and friction.. This resilience from the secondary pinions gives greater isolation to the gear



Reversing



By application of either the ahead or astern brake the direction of the output shaft can be controlled. This system act as an alternative to a reversing engine or CP propeller.