9 Load sharing

Design of epicyclic gear drives should address distribution of transmitted power between each of the parallel power paths if the configuration contains more than one planet gear in the system. Concerning multiple path transmissions, the total tangential load is not quite evenly distributed between the various load paths (irrespective of design, tangential velocity, or accuracy of manufacture). Allowance is made for this by means of the mesh load factor, K_γ.

$$K_\gamma = \frac{T_{Branch} N_{CP}}{T_{Nom}} \quad (35)$$

where

T_{Branch} is torque in branch with heaviest load;

T_{Nom} is total nominal torque.

If possible, K_γ should be determined by measurement. Alternatively, its value may be estimated from table 8.

K_γ is equal to or greater than 1.0. K_γ equals 1.0 when all planets are assumed to equally share the load. K_γ is greater than 1.0 when it is assumed that one planet will carry more than its equal share of the total load.

9.1 Float

An approximate theoretical analysis suggests that equal load sharing with 3 planets can be achieved by allowing one of the coaxial members to float. Load imbalance can still be caused by dynamics of coupled stages and must be addressed by detailed analysis. This dynamic analysis must consider the accelerating forces required to move the floating member to a position of equilibrium. Load equalization causes the floating member to follow an orbit which is dependent on dimensional variations of all the members.

9.2 Load share

Some methods utilized to improve load sharing are:

- higher quality gear members;
- increased precision of carrier elements which locate planet gears;
- matching planet gear sets by tooth thickness;
- improve tooth alignment of compound planets by using matched sets of planets (compound epicyclics only);
- oil film thickness variation due to changes in oil flow and loads in journal bearings;
- allowing radial float of one or more elements;
- elastic deformation of ring or the sun gear, or both;
- reducing tooth stiffness;
- elastic deformation of planet gear shafts;
- elastic deformation of planet carrier;
- eccentric planet shafts with load responsive rotation device;

Table 8 - Mesh load factor for the heaviest loaded planet

Application level 1), 4), 5)		Number of planets, N_{CP}								AGMA accuracy grade 2)	Flexible mounts 3)
		2	3	4	5	6	7	8	9		
1	K_γ 6)	1.16	1.23	1.32	1.35	1.38	1.47	1.60	~	A7 or worse	without
2	K_γ 6)	1.00 7)	1.00 7)	1.25	1.35	1.44	1.47	1.60	1.61	A5-A6	without
3	K_γ 6)	1.00 7)	1.00 7)	1.15	1.19	1.23	1.27	1.30	1.33	A4 or better	without
4	K_γ 6)	1.00 7)	1.00 7)	1.08	1.12	1.16	1.20	1.23	1.26	A4 or better	with

NOTES

1) Application level 1 typical for slow speed gears, mining mill drives, etc.;
2 moderate quality, i.e., commercial marine, non-military;
3 & 4 high quality, high speed, gas turbine/generator drives, military marine, wind turbines.

2) Gear manufacturing quality has an influence on the load sharing performance of the planets. Higher gear quality results in reduced load variations through each planet mesh.

3) Flexible mounts of the planets, such as flexible shafts or pins, flexible planet couplings or flexible annulus improves load sharing. See 9.2.

4) Load sharing level 2 or higher requires at least one floating member.

5) Load sharing level 3 or higher requires a flexible ring gear.

6) Mesh load factor, K_γ, is the product of the number of planets times the L_f factor in ANSI/AGMA 6123-A88.

7) A value of 1.00 may not be conservative enough for applications where the sun mass is high in relation to the speed and the radial forces required to accelerate the sun are significant.

