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Calculation of load capacity of spline

花键承载能力计算方法

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Calculation of load capacity of spline

1 Scope

This standard specifies the calculation method for the load capacity of cylindrical straight tooth involute splines and cylindrical rectangular tooth splines (hereinafter referred to as splines).

This standard applies to splines manufactured in accordance with GB/T 1144 and GB/T 3478.1. Other types of splines may refer to this standard.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this standard.

GB/T 1144 Straight-sided spline - Dimensions, tolerances and verification

GB/T 3478.1-2008 Straight cylindrical involute splines - Metric module side fit - Part 1: Generalities

3 Terms and codes

Terms and codes are as shown in Table 1.

Rectangular spline:

$$W = F_t / (Z \cdot l) \quad \dots\dots\dots (5)$$

4.2.4 Calculation of shaft load F and bending moment M_b :

The shaft load F and bending moment M_b of the spline pair shall be calculated after force analysis according to the specific transmission structure.

5 Factor

5.1 Use factor K_1

The use factor K_1 is mainly a factor that considers the influence of power overload caused by external factors of the transmission system. The impact of this overload depends on factors such as the characteristics of the prime mover (input) and the working machine (output), the mass ratio, the mating nature and accuracy of the spline pair, the operating status, etc.

The coefficient can be obtained by precise measurement, or it can be determined after analyzing the whole system. When the above method cannot be realized, it can refer to Table 2 for values.

Table 2 -- Use factor K_1

5.2 Tooth side clearance factor K_2

When the stressing state of the spline pair is as shown in Figure 4, the load on the teeth of the involute spline or rectangular spline depends on the elastic deformation of the key teeth; it also depends on the size of the side clearance of spline pair. Under the action of the shaft load, as the backlash changes (half of the circumferential gap increases, the other half of the circumferential gap decreases), there will be a relative displacement e_0 between the two axes of

the inner spline and the outer spline, as shown in Figures 4 and 9. The magnitude of the displacement e_0 is related to factors such as the size of the backlash (clearance) of the spline and the level of manufacturing accuracy. After the displacement occurs, the load is distributed on fewer key teeth (the self-centering effect is lost for the involute spline), which affects the load-bearing capacity of the spline. The side clearance factor K_2 considers of this impact, usually $K_2 = 1.1 \sim 3.0$.

When the shaft load is small and the accuracy of the spline pair is high, it may take $K_2 = 1.1 \sim 1.5$; when the shaft load is large and the accuracy of the spline pair is low, it may take $K_2 = 2.0 \sim 3.0$; when the shaft load is zero and only bearing the rotational moment (see Figure 2), $K_2 = 1.0$.

5.3 Distribution factor K_3

When the two axes of the inner spline and the outer spline of the spline pair are coaxial, the theoretical backlash (single tooth backlash) of the spline pair is different due to the influence of cumulative error of the tooth pitch (indexing error); the load on each key tooth is also different.

The distribution factor K_3 considers this influence. For the spline pair before running-in, when the accuracy is high (the precision rectangular spline according to the GB/T 1144 standard or the accuracy level according to the GB/T 3478.1-2008 standard is level 5 or higher), $K_3 = 1.1 \sim 1.2$. When the accuracy is low (the general use rectangular splines according to the GB/T 1144 standard or the accuracy level according to the GB/T 3478.1-2008 standard is lower than level 5), $K_3 = 1.3 \sim 1.6$. For the spline pair after running-in, when each key tooth is involved in the work, and the load is basically the same, take $K_3 = 1.0$.

5.4 Axial eccentric load factor K_4

Due to the tooth orientation error produced during the manufacture of the spline pair and the concentricity error after installation, as well as the torsional deformation after being loaded, the load on each key tooth along the axial direction is uneven. The axial eccentric load factor K_4 is used to consider this. Its value can be selected from Table 3.

For the spline pair after running-in, when the axial load distribution of each key tooth is basically the same, it takes $K_4 = 1.0$.

When the accuracy of the spline is high and the indexing circle diameter D or the average circle diameter d_m is small, the axial eccentric load factor K_4 in Table 3 shall be the smaller value, and vice versa.

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