8 Relationship Between Tolerances and Production Distributions

8.1 Direct and Indirect Function Characteristics

The ideas we have discussed so far:
- basic statistics for quantitative characteristics,
- mixed distributions, and
- folding operations,

should in this and the following chapters now be applied to tolerances, fits (two member dimensional chains) and multiple dimensional chains.

All characteristics given in production specifications (drawings) such as dimensions or material characteristics must usually fulfill a specific function for which they are intended.

- All characteristics are functional characteristics and therefore important for quality and reliability of technical products.

A distinction can be drawn between
- direct functional dimensions (characteristics) and
- indirect functional dimensions (characteristics).

This can be explained with the example of a gear shaft, which is positioned on both sides, Fig. 8.1. At the middle next to the pivot pins, 1 and 5, are the shaft recesses on both sides for the gear wheels, 2 and 4; the shaft section with the greatest diameter is in the middle, 3.

Direct functional dimensions are in Fig. 8.1 the diameters 1 and 5 or 2 and 4. They appear in direct function (in interaction) with the inner diameters of the pivots or gear wheels.

These direct functional characteristics are therefore especially important. The following points are valid for them:
- They must have narrow tolerances and therefore
- must be produced with high precision
- so careful quality control must be planned and carried out, so that
- a controlled process is ensured.
- Only small proportions of dimensions exceeding limit values (errors) can be accepted.
Direct functional characteristics are test values in the sense that they must be taken into account in test planning concerning the test sample quantity. Test sizes can be shown in a special way in a drawing:

1. Example:

\[
\begin{array}{c}
25^{+0.03}_{-0.03}
\end{array}
\]

Zeppelin shaped dimension; test dimension

2. Example:

\[
\begin{array}{c}
25^{+0.05}_{-0.05}
\end{array}
\]

Bar dimension; Test dimension with which in addition the internal works specification for the actual dimension distribution in the tolerance field must be taken into account.

Further examples for direct functional characteristics are

- thread pitch diameter of a spindle,
- pitch circle of a gear wheel,
- piston diameter and cylinder diameter of an engine.

The diameter of the shaft Sect. 3 in the middle of the shaft in Fig. 8.1 belongs to the indirect functional characteristics. This diameter appears with no other dimension in a direct function. It fulfills its function indirectly in that it serves to ensure that the limit value of the flexing of the shaft or the limit value of the bending edge tension (permissible tension) is not exceeded.

Indirect functional characteristics are not especially important. For these the following points should be taken into account:

- They can have wide tolerances and therefore can be produced with average or low production precision and often need no quality control or quality testing.
- Certain proportions of dimensions which exceed limit values (errors) can be accepted, if these occur despite the wide tolerances. Non-comformity must only be rejected if as a result the part is considered unacceptable.

Note: If the diameter in the middle of the shaft in Fig. 8.1 for example with \(60 \pm 0.15\) (general dimension with "fine" tolerance class) is not achieved, then it is not likely that shafts with the actual dimension \(d = 59.80\) will adversely affect the function (not exceed the limit bend).