Self-tapping screws for thermoplastics
• Dimensions for screws and screw holes
• Suitable Covestro thermoplastics

Introduction

Disconnectable joints for plastics parts which are achieved through the use of self-tapping screws have been successfully employed for a long time, since they are both reliable and inexpensive. The pull-out strength of self-tapping screws is similar to that of screw connections achieved with molded-in threaded metal inserts. Providing that the parts are assembled correctly, there will be no greater danger of stress cracking than with threaded metal inserts. Incorrect assembly, however, may result in damage to the thread.

The quality of a screw connection

The following factors have a key influence on the quality of a screw connection:
A – screw-in torques
B – geometry of the screw and screw boss
C – torque cut-off
D – screw insertion speed

A – Screw-in torques

The insertion torque ME denotes the maximum torque that occurs as the screw is being inserted, prior to the screw head coming into contact with the surface against which it will rest. The torque employed to tighten the screw is the tightening torque, MA. This should be at least 1.2 times the insertion torque, but should not exceed 0.5 times the stripping torque MÜ, required to strip the thread (Fig. 1). The insertion torque and stripping torque should be determined experimentally. The higher the ratio of MÜ to ME, the more reliable the screw connection will be.

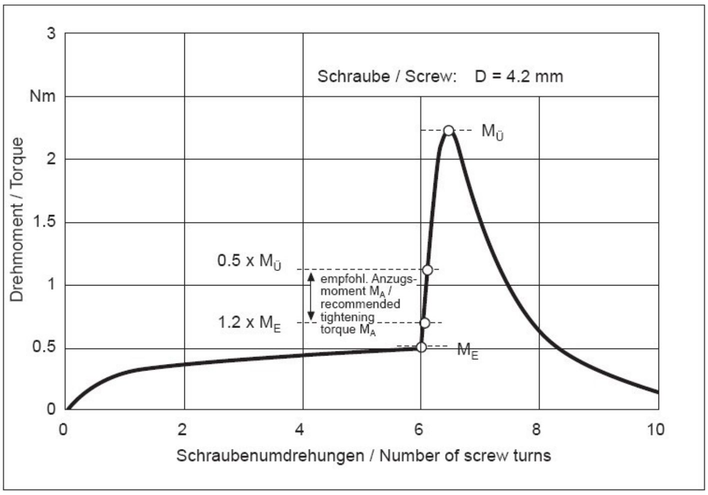


Fig. 1: Screw-in torques for a typical plastic (ME = insertion torque, MA = tightening torque, MÜ = stripping torque)

B – Geometry of the screw and the screw boss

1. Screws:

Geometries with the following characteristics have proved suitable:

– sharp-angle thread < 40 °
– small core diameter < 0.65 x D
– high thread pitches > 0.35 x D
– tight manufacturing tolerances

Countersunk-head screws are not suitable for thermoplastics on account of their expanding effect.

1.1 Screws with a cutting notch:

These screws cut the thread and are suitable for once-only assembly or for connections that only need to be disconnected and re-assembled a few times. They are characterized by a low insertion torque ME and a relatively high stripping torque MÜ, which means that their MÜ/ME ratio is particularly favorable. The drawback to this type of screw is that repeated assembly is only possible if the screw is carefully reinserted into the original thread (by hand). Problems can thus be encountered in respect of compliance with VDE 0700.

1.2 Screws without a cutting notch:

All the screws of the design shown in Fig. 2 are suitable for thermoplastics, providing that the dimensioning rules for the screw boss are observed (Fig. 3). These will then generally fulfil the VDE requirements as well.

Advice on less suitable screw geometries

In isolated cases it may be necessary, for logistical reasons, to have recourse to less suitable screw geometries, such as sheet-metal screws, which do not comply with the specifications in Fig. 2. Since this can lead to increased strain on the screw boss, the geometry of the boss has to be modified in the appropriate manner. Table 1 shows the design dimensions (in brackets) that have proved successful. In view of the considerably higher loads acting on the plastic, tests should be conducted for purposes of establishing the serviceability of the connection.

Kerndurchmesser / Core diameter D_K (mm)	< 0.65 x D
Gewindesteigung / Thread lead P (mm)	0.35 x D bis / to 0.55 x D
Flankenwinkel / Thread angle α	< 40°

D = Gewindedurchmesser[1)] / Thread diameter[1)]

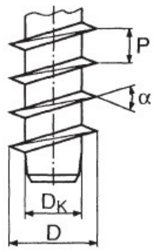
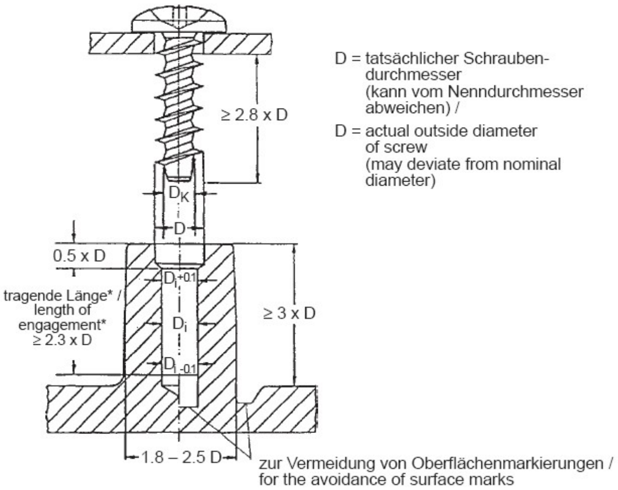


Fig. 2

[1)] NB: The nominal diameter may deviate from the actual outside diameter since different tolerances are employed for different screw types.

Table 1
Self-tapping screws without cutting notches
Recommended dimensions for screw holes (valid for D = 2.9 to 5.1 mm)

Material	For the screw geometry given in Fig. 2
Bayblend® (with low PC content)	Di = 0.86 x D
Bayblend® (with high PC content)	Di = 0.89 x D
Makrolon® (non-reinforced)	Di = 0.90 x D
Makrolon® (glass fibre reinforced)	Di = 0.92 x D
Apec®	Di = 0.90 x D



* Je größer die Einschraubtiefe, desto besser werden VDE-Vorschriften erfüllt

* The greater the screw-in depth, the better the compliance with VDE regulations

Fig. 3

B – Geometry of the screw and the screw boss

2. Boss geometries:

In the case of a standard screw connection, the boss geometry should comply with the recommendations given in Fig. 3. The hole diameters should display a tight tolerance in order to guarantee a consistent quality.

If the relatively high tightening torque means that the connection fails to comply with the requirement for assembly and disconnection ten times over, as specified in VDE 0700, then the remedy that is frequently adopted in practice is to reduce the diameter of the hole. This, however, leads to greater expansion of the boss and hence to higher tangential stresses, which, in turn, increase the danger of long-term stress-cracking with ultimate failure. The best way to reliably absorb higher tightening torques is to increase the screw-in depth. This leads to just a slight increase in the insertion torque but raises the stripping torque quite considerably and hence also serves to increase the permitted tightening torque.

C – Torque cut-off

When self-tapping screws are used, the connection is frequently damaged at the assembly stage on account of excessively high tightening torques being employed. The most frequent reasons for this are:

– the kinetic energy of rotating nut runner masses that cannot be braked quickly enough on account of the inertia of the mass (this frequently occurs at high speeds and with small screw diameters)
– an incorrectly estimated or unknown stripping torque
– excessively small screw-in depths

D – Insertion speed

With the right insertion speeds, sufficient frictional heat will develop to slightly melt the plastic in the region of the thread flanks. This will then make it easier for the thread flanks to penetrate the plastic, thereby reducing the tangential stress and increasing the stripping torque at the same time.

If excessive frictional heat prevails (on account of high nut runner speeds), the area of plastic that melts will become greater while the stripping torque decreases, leading to a reduction in the quality of the screw connection (Fig. 4).

With only a low level of frictional heat (low nut runner speed, manual screw insertion), high tangential stresses will develop in the screw boss, leading to a poorer-quality screw connection.

Since the frictional heat is additionally influenced by the screw-in depth and the surface characteristics of the screws employed, it is advisable to conduct a number of application- based tests in order to establish the optimum nut runner speed. Screw circumferential velocities of between 3 and 6 m/ min have proved successful for molded parts made of Covestro thermoplastics. For screws with a nominal diameter of 4 mm, this corresponds to a nut runner speed of 250 to 500 r.p.m.

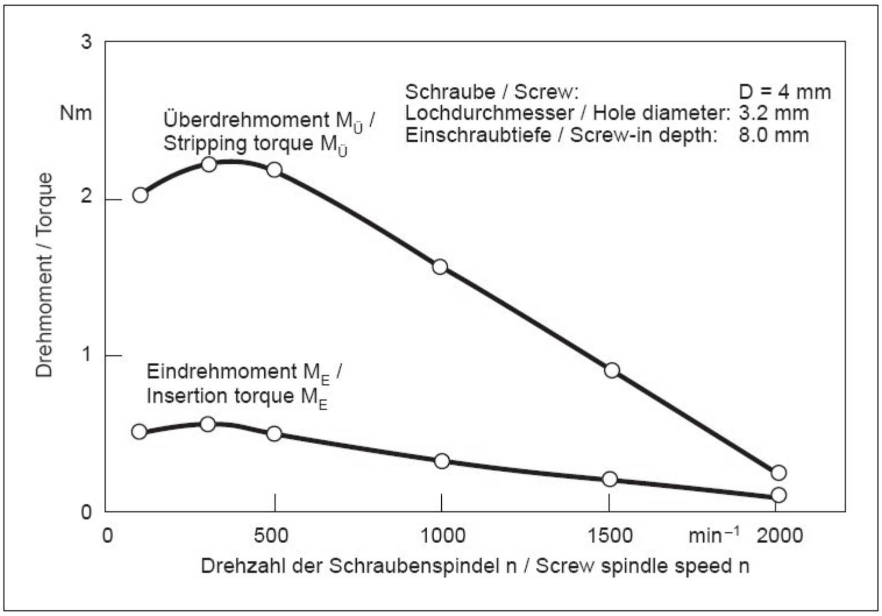


Fig. 4: A typical plastic

NB

The no-load speed specified for standard commercial nut runner units is frequently much higher than the speed actually attained under load.

The screws used should be free from production residue. This could be cutting oil or rust protection media.

If necessary the effect of these media on the plastic should be tested. Certain media can lead to stress cracking in the area of the screw connection and thus lead to the failure of the connection. Stress cracking can occur a long time after the screwing.

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