Categorization of Poly-functional Fasteners

by Jozef Dominik

As it is generally known an assembly has not insignificant share on laboriousness of machines and devices production. Depending on a kind of product it can make up to 30 and more percent out of total production time. Hence, it is important for producers to select such technological procedures that will cut assembly costs. Using poly-functional fasteners are one of ways how to reach it.

Introduction

Poly-functional (incorrectly called – multifunctional) fasteners are such ones, which besides general function (i.e. joining single parts into technological units) are also able to fulfil secondary functions such as drilling a bore under the thread, threading, protection, a gasket, a washer function and so on. Each of these auxiliary functions contributes to assembly rationalization that cannot be understood as an isolated technological operation but only in mutual synergic relation with joined parts and fasteners. This is important mainly within the serial production. For instance, it is hard to imagine automatic assembly with the help of common fasteners according to **Fig.1** (left one). Two assembly directions and too many assembly elements (a screw, a nut, a flexible and flat washer = altogether 4) pervert it almost at all. To the contrary a structure with nut-free flanging joint in the right-hand side of the picture simplifies significantly an assembly and logistics, it not only replaces a common solution from the functional point of view but also overcomes it.

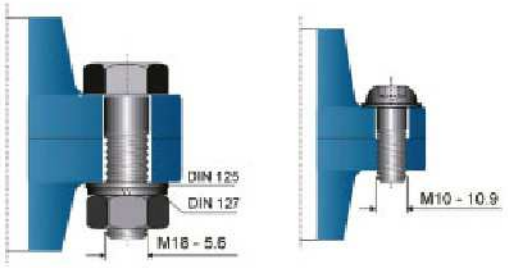

Fig.1 Inappropriate Structure (left) and Rational Solution (right)
图一 不适当的结构（左图），具经济效益的结构（右图）

The example in **Fig.1** is not rare in regular practice. It was scientifically based and practically tested many times that flexible washers according to DIN 127 are not reliable prevailing element; furthermore, they are characterized by high dispersion of attributes, so they increase the amount of partition lines unnecessarily and make logistics complicated. If constructors are still using them they are either unknowing new trends or as a result of deep-rooted conservatism which prevents them to use progress in fastener technology. A current fastener market offers a wide assortment of modern sophisticated elements used for mechanical fastening. The offered contribution is an attempt for their categorization on the basis of the poly-function degree (PFD) as you can see in **Table 2** at the end of the article and with its help it should help to the selection from them. It should also contribute to the education in the field of rational assembly.

综合功能紧固件的分类

文 / Jozef Dominik

众所周知，组装件在机器设备生产工时所占比例不轻。视产品类别而定，组装件可能占总生产工时 30%以上或更多的比例。因此，对于生产制造者来说，选用降低组装成本的高科技制程是很重要的。使用综合功能紧固件就是达到这目标的方式之一。

简介

综合功能紧固件(常被误为多功能紧固件)除了能将单一部件接合到高科技组件的功能之外，同时也具有次要的功能，例如，以螺纹牙攻钻孔洞，滚轧螺纹，或作为防护衬垫和华司的功能等。每项辅助功能都有助于组装经济效益的提升，组装的经济效益不在于高科技独立单一的运作系统，而在于接合件与紧固件共同协合的关系。这个概念在成批生产中尤为重要。常用的紧固件很难有助于如图一左图所示的自动化组装。两种组装方向以及过多的组装元件，（一支螺丝，一支螺帽，一个弹性扁平华司）都让装配变得异常困难。图一右图所示的组装结构却不然，接合两边都没有螺帽，让组装和递送过程大大简化，此种结构不仅替代常见的方案，以解决功能上的需求外，还就此克服组装困难的问题。

Characteristics and Selection of Poly-function Fasteners

Screws & Nuts with Flange or with an Integral Washer

The screws and nuts with an integral washer respectively flange **(Fig.2)** are the typical example of poly-function fasteners.

The degree of their poly-functionality (PFD) is possible to increase by the appropriate increase of contact surfaces friction coefficient by profiled toothing or ribbing, hence they can serve both as reliable prevailing elements.

◆ Advantages

- Enlarged contact surfaces resulting to lower surface pressure on joined parts:

$$p = \frac{F}{S} \ [\mathrm{N/mm2}]$$

(p – surface pressure, F – stress having effect on a joint, S – contact surface)

- Simple logistics due to smaller amounts of assembly parts
- A small number of partition lines, therefore there is a smaller total material seating on these lines and risk reduction of slit corrosion
- Simple assembly
- An alternative with ribbed (toothed) contact surfaces functions as a reliable prevailing element against self-loosening
- A possibility to furnish with a flange any kind of a screw head and nut, for example also external Torx **(Fig.3)**
- Easy availability on the market

Tek Screws

Also one of many from the category of poly-functional fasteners is self-drilling screws popularly called Teks **(Fig.4)** which are able to drill a bore and cut a thread alone during assembly **(Fig.5)**. They are suitable mainly for joining sheets steel and steel profiles. Recommended sheet steel thickness is shown in **Table 1**.

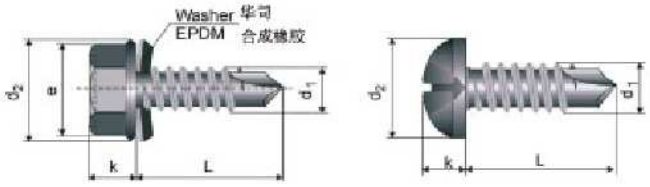

Fig.4 Self-Drilling Tek Screws
图四 Teks 钻尾螺丝

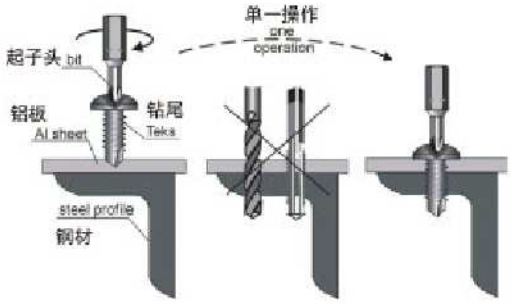

Fig.5 An Example of Using Tek Screws
图五 Teks 钻尾螺丝应用实例之一

Fig.2 Screws & Nuts with Integral Flange
图二 内建法兰结构的螺丝和螺帽

Fig.3 External Torx with a Flange
图三 具法兰结构之外部 Torx

图一所示例子并非罕见。科学实验多次证明，符合DIN 127标准的弹性华司垫片并不能当作可靠的预置扭矩防松元件；再者，由于高度发散的特性，而增加的不必要分隔线，反而造成递送过程的困难。建造者若还使用这种华司，他们一定对于潮流趋势浑然无知，否则就是有根深蒂固的守旧观点，因而无意采用新技术在紧固件发展上。呈现在时下紧固件市场的是使用在机械式紧固技术的各种不同特性和复杂功能的元件。依据综合功能程度 (Poly Function Degree, PFD)，本文尝试将综合功能紧固件区分为文末表二所示的几个类别，以此为选择的依据。另外，借此篇文章，愿提升业界对于组装经济效益的概念。

Table 1 Recommended Sheet Steel Thickness h [mm]

表一 板钢厚度建议标准 h [mm]

d_1	2,9	3,5	(3,9)	4,2	4,8	5,5	6,3
h [mm]	0,7 – 1,9	0,7 - 2,25	0,7 - 2,4	1,75 - 3,0	1,75 - 4,4	1,75 - 5,25	2,0 - 6,0

◆ **Advantages**

- Costs saving caused by the absence of the drilling a bore operation and thread cutting.
- No problem with holes reseating
- Simple logistics
- Nut-free, clear joint
- Rational assembly

They are made of steel, stainless steel or as a combination of them where a head and a waist of a screw are of austenitic stainless steel A2 and to this there is soldered a small steel drill. The difference between particular variants is shown in **Fig.6**. On the basis of this, constructors can decide which combination of parameters they will prefer when constructing.

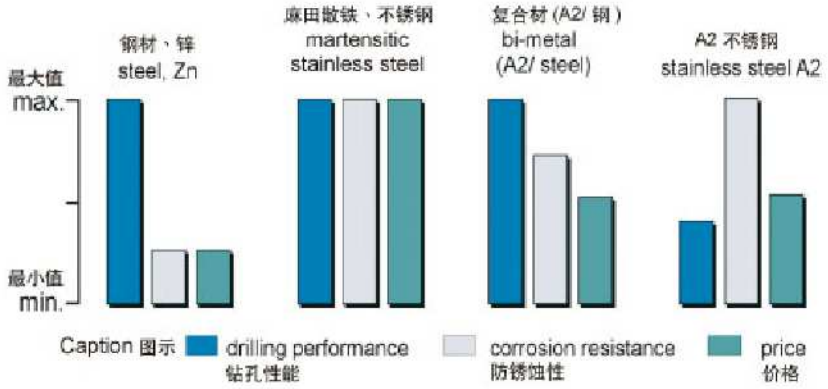

Fig.6 Comparison of Screws Teks from Various Materials

图六 不同材质钻尾螺丝的比较

Wing – Tek screws with milling tools under head with the highest PFD degree belong to this category of self-drilling parts (shown in **Table 2**) which are even equipped with the ability of drilling a crossing hole with the help of special wings and they are able to be countersunk by itself because they have countersunk head equipped with small millers. They are often used when joining wooden flooring of lorries on steel skeleton.

Tek Screws —Triangular Cross-section Screws

It is worth to mention triangular cross-section screw (hereinafter TCS) **(Fig.7)** which creates a counter-thread by forming, hence by non-cutting way contrary to self-cutting screws. By that a strong joint is attained. In order to make assembly easier it has 3 or 4 run-on threads. TCS screws are often used especially in electrical engineering industry when joining A1 – profiles.

综合功能紧固件的特性和具代表性类别

法兰结构或内建华司的螺丝和螺帽

具有内建华司或法兰的螺丝和螺帽（**图二**）就是典型的综合功能紧固件的例子。

综合功能紧固件可借由锯齿状或肋状结构，以增加接触表面摩擦系数的方式来提高性能，因此，这两种综合功能紧固件都可作为可靠的预置扭矩防松元件。

◆ **优点**

- 接触表面加大，因而降低接合部件的表面压力：

$$p = \frac{F}{S} \quad [N/mm2]$$

(p - 表面压力，F - 接合部位所受应力，S - 接触表面)

- 组装件数量少，组装递送过程也随之简化
- 分隔线少，因此减少分隔线上材料占据的空间，缝隙部位腐蚀风险也因而降低
- 组装简单
- 肋状（锯齿状）结构的接触表面具备高可靠度且避免自松弛现象
- 可设计法兰结构于任何型式的螺丝头部和螺帽，如外部 Torx（**图三**）
- 市场上采购便利

Teks 钻尾螺丝

综合功能紧固件的类别中的其中一种是钻尾螺丝（**图四**），通常称为 Teks，能够在组装过程中进行钻孔或切削螺纹（**图五**）。这些钻尾螺

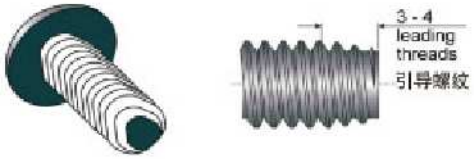

Fig.7 Triangular Cross-section Screw
图七 三角断面螺丝

Fig.8 Costs Structure on a Bolted Joint
图八 螺栓接合的成本结構

◆ **Advantages**

- It practically eliminates chips
- Low thread forming torque
- Excellent resistance to vibrational loosening
- It reduces total assembly costs

Naturally, there are much more fasteners with the attribute of poly-functionality than this short contribution presents. Equally, in **Table 2**, which is the first attempt to categorize these elements, there are presented only some representative types of them because it was not our intention to provide exhaustive list of all known poly-functional fasteners. What is more important is to highlight the existence of them and provoke the interest of constructors not only to use them in practice but also develop new kinds in order to improve and further automatize the assembly process. Here is valid a generally known rule 20/80 **(Fig.8)** according to which the total costs on realized bolted joint are made out of 20% of price only, the rest are technology and logistics. Therein lies the biggest rationalization potential.

丝的应用主要适合板钢与板钢侧面的接合。板钢厚度建议标准如表一所示。

◆ 优点

- 无需任何钻孔或螺纹切削，组装成本得以降低
- 装设新孔方便
- 递送过程简单
- 完全不需螺帽，接合部位无障碍
- 组装合乎经济原则

Teks 钻尾螺丝的制作材质为钢材、不锈钢材，或者头部与腰部为 A2 奥斯田不锈钢材 (austenitic stainless steel A2)，而其上焊接钢材钻凿装置。不同材质的钻尾螺丝其钻孔和防锈蚀性能以及价格如图六所示。建造者可以此为参考依据，决定所需要的参数组合。

头部下方具有铣削刀具的翼状结构 Teks 螺丝是具有最高综合功能 (Poly Function Degree, PFD) 的钻尾螺丝。这一类的钻尾螺丝（**表二**）因为其凹陷的头部设计有小小的铣子结构，加上其特殊的翼部结构，且本身就是沉头式结构，因此具有十字型孔的钻凿功能。这种沉头式钻尾螺丝常应用于载货卡车的木质地板与钢材骨架的接合。

Teks 钻尾螺丝 —三角断面螺丝

值得一提的是横断面近似三角形的螺丝（以下称三角断面螺丝，triangular cross-section screw, TSC）（**图七**）。这种三角断面螺丝借由成型制造产生相应螺纹，与其它在本体切削出螺纹的螺丝不同。经由这种方式产生的是非常紧固的接合。为了使组装更简单，三角断面螺丝有三至四转连续螺纹。三角断面螺丝通常应用在电机工程 A1 不锈钢材的接合。

◆ 优点

- 完全排除组装产生的切屑
- 低螺纹成型扭矩
- 抗振性高，不致松脱
- 总组装成本低

除了本文所提及的，当然还有更多具综合功能的紧固件。**表二**仅尝试列举出较具代表性的类别，因为本文目的并不在提供一个清单，列出所有已知的综合功能紧固件类别；重要的是要凸显综合功能紧固件的存在，唤起建造者的兴趣，不仅是在实作中采用这一类的紧固件，更希望建造者发展新的种类，如此才能改进组装过程及将其自动化。有关成本，这里要提到一个常见的 80/20 比例原则 （**图八**）。根据这原则，总组装成本中，以螺栓接合的成本应该只占百分之二十，其余的比例为技术及物流成本。这部分正是组装经济效益的最大潜能所在。

Table 2 Categorization of Fasteners according to the Poly Function Degree (PFD)
表二 综合功能紧固件依综合功能程度（PFD）的分类

Representative Selection 具代表性类别	Characteristics 特性	Functions 功能	PFD
	• Simple nuts & bolts • 简易型螺帽&螺栓	• joining 接合	1
	• Unshaped flange elements • Lock nuts • Self tapping screws • 不固定型法兰紧固元件 • 防松螺丝 • 自攻螺丝	• joining 接合 • or washer 或华司 • or locking 或锁紧 • or threading 或攻牙	2
	• Shaped flange elements • Triangular cross-section screws- TCS • 固定型法兰紧固元件 • 三角断面螺丝 - TCS	• joining 接合 • washer 华司 • locking 锁紧 • or forming of thread 或螺纹成型	3
	• Self drilling screws (Teks) • 钻尾螺丝（Teks）	• joining 接合 • locking 锁紧 • drilling 钻凿 • threading 攻牙 • or washer 或华司 • or gasket 或衬垫	4 ÷ 5
	• Wing - teks screws with milling tools under head • 翼状结构Teks螺丝，头部下方具有铣削刀具	• joining 接合 • locking 锁紧 • drilling 2x 双重钻凿 • threading 攻牙 • embeding 嵌入	5 ÷ 6

Conclusion

As it was stated above, poly-functional fasteners present significant rationalization potential and it is to the detriment of it that they are not used in its full extent. Highly sophisticated PFD from 4 to 6 fasteners are not any rarity today. They are easily available on the market. There still has been missing their systematic categorization, which would provide practical data on particular types and mainly on their contribution for theory and practice of mechanical joining.

结论

如前所述，综合功能紧固件为组装经济效益带来重要的发展潜能，但可惜的是这项发展没有在实际应用方面得到全面的重视。4~6 支高程度综合功能的紧固件应用实例目前并不少见，在市场上也容易取得。然而，目前仍缺乏有关综合功能紧固件系统性分类的知识，因为有系统的分类知识才会产生各种类型的实用数据，更重要的是，如此一来才能了解综合功能紧固件对于机械接合理论和实务的贡献。