Sustainability – To Use Once or to Reuse, That is the Question?

by Peter Standring

A curious fact of life of which we are all well aware is that change is always taking place. And yet, it is often so imperceptible that we simply never notice it. Daily life is just that, it occurs daily and for most people, consists of doing similar things over again. Even when on vacation, in our minds we know that what is taking place is only temporary and before too long we will once again assume the comfort of our everyday existence.

Occasionally the cumulative imperceptibility of change hits us with a force which can shake our core. A good example is a return to a place we were once very familiar with. To the people who have lived there continuously, nothing remarkable will have happened but to the returnee, buildings may have been replaced, road systems changed beyond recognition and perhaps most telling, old friends and acquaintances have become much older. This discontinuity between the gradual and cumulative change often forms historical boundaries with which we identify the past. Horseless carriage comes to mind, as does air travel, antibiotics and digitisation. In short, the unthinkable happens when; horse drawn transport is replaced, passenger liners become redundant, life threatening illnesses are cured and the generation of big data is born.

Looking back, we can discern such moments in time and credit them with the importance they deserve. But what about being really smart and spotting those changes which are happening now and extricating their significance from the imperceptible flow of every day change?

Game Changers

These fall into two categories, one due to natural, often cataclysmic events, the other through human developments. Although the discovery and control of fire may seem outdated, it still transforms many of our materials, is involved in most food production and is the energy source which powers most of our transportation. But things are changing primarily driven by the recognition that, as yet, we only have one place to call home and making it unfit to live in, is a rather stupid notion.

The increasing development of hybrid and full battery powered engines both for land and air transport will provide the gradual step change which two decades ago was just an environmentalist's dream and in two more decades will be the new norm. For those experiencing the change it will appear incremental, however when viewed from an historic perspective, it will be a game changer.

So how will this affect the fastener industry and perhaps, of greater importance, how might such a dislocation in development be considered when it is just one example of many?

For the fastener industry, the variety, use, development and rationalisation of engine components – as described in a previous article for Fastener World (Fastening: Yesterday with Today and Tomorrow, Issue 166, Sep/Oct 2017) – will be totally displaced by the demand for long bolts to hold the laminations needed for electric motors. Naturally, the introduction of all electric drives will also impose major change on the rest of the drive train.

However, fundamental as this will prove, it is probably more important to consider the reasons for such change and, where fasteners are employed, the possible knock-on effects this might have elsewhere for the other none transportation sectors.

Sustainability

In the early 1970's much pontification took place regarding the Planet running out of oil – by 1990 I seem to recall. Today, we are told that at the current usage, there are sufficient reserves to last for 300 years but it may be expensive to extract. So, electrification of transport is not driven by a need to conserve resources but by a demand to depollute where we live and to help stabilise the climate. This is also true for the reduction of oil based polymers the particles of which are now entering the food chain at an alarming rate. Global manufacture exploits the earth's resources and once the purpose of the product has been served, these are discarded. This is particularly true for single use products which means virtually all packaging, disposable products and hard copy media/communications. It is this trend and the scrutiny of single use products related to the fastener industry which the article addresses in the hope of perhaps influencing its future direction before possible external legislative demand makes us do so.

Types of Fastener Use

The selection of fastener types to fulfil a design requirement incorporates function cost, availability, etc.. Each of these categories also contain sub elements which, like a Venn diagram, may overlap. For example, materials, surface treatment, delivery.

Single use fasteners as the term implies, suggests an item which like a paper staple, would be applied once. An equivalent reusable fastener would be a paper clip which might be expected to be applied any number of times until it is lost or broken by someone aggressively playing with it.

Taking the paper staple example, its life might end when the papers which it holds are consigned to a waste bin. Alternatively, it might have its two prongs opened and the pages it held released, or simply be torn off to separate them. The staple design makes it very unlikely to be reused.

This rather trivial example is significant because the utility and life cycle of a paper fastener is no different than the close to 100 million vehicles which are currently produced annually. In a previous Fastener World article which dealt with vehicle manufacture (Fastening: A Future. Opportunities for Automotive Fasteners to Change the World – Issue 164, May/Jun 2017) it was suggested that the humble fastener held the key to Design for Disposal.

A paper clip will allow pages to be rearranged, separated and/or disposed of much easier than when a staple is involved.

On high value vehicles, multi materials (both metal and composites) are adhesively bonded and secured by the use of self piercing rivets. Interestingly, this is not the case in the manufacture of high end golf 'woods' where a range of lightweight metals and non metals are only bonded, yet rarely fail despite repeated impacts delivered by some very aggressive young athletes chasing multi million dollar prize money!

In every branch of engineering, be it general, construction, automotive (from F1 to tyre dealers), they all utilise reusable fasteners. In short, the ubiquitous nut and bolt can be found in any engineering workshop and is used on virtually all scaffolding and heavy lifting equipment. It of course helps achieve the two second tyre changes which too often in today's events substitute for the lack of overtaking capability on the F1 race track.

For efficient production, the ability to join items must be quick and low cost. Couple this with the advantage of rapid reuse and ultimate ease of disassembly for remanufacture or disposal and a new attribute of value enters the Venn Diagram.

The reward for quick wheel change to F1 race teams is reflected by the expense they go to to achieve it. In the same way, every commercial dealership which sells replacement tyres use power tools to undo and replace wheel nuts quickly. However, whilst this is the norm for those employed in a specific area, it will not improve the efficiency of screwing a nut on a bolt. To do this faster requires a different design.

Fast Acting Fasteners

Like most boys in the 1950's, my Saturday morning cinema delight often revolved around American made black and white 'B' movies in which cowboys were involved. The term 'Badlands' was frequently used which I assumed was where 'Badmen' hid out from the good guys in the white hats. It was only much later when I drove through many of the Western States of the USA that I discovered the name 'Badlands' referred to the terrain and not the people. These were areas where the lumps and bumps in the landscape made it virtually impossible for wheeled transport, 'the covered wagons', to make any reasonable forward progress. A high pass between two mountains is worth making a major effort to cross if the land on either side is negotiable.

The same comparison can be made in screw threads. A fine or short 'pitch' will produce a shallower thread than one with a bigger 'pitch'. However, the greater the number of shallow fine pitch threads over a given distance will provide less chance of a thread stripping than where a larger pitch, deeper thread is used. The problem that that is it takes much longer to screw a fine pitch nut on to a bolt than one with a larger pitch and of course the chance of 'crossing' the thread is increased.

Multi Start Threads

The 'lead' of a screw is the distance a nut would travel in one 360 degree rotation. In single start screws, the 'lead' and pitch are the same. However, if the 'lead' (the helix angle of the thread) is a multiple of its 'pitch', by 2, 3, 4 or more, then the distance a nut would travel in one rotation would be twice, three, four or more times the pitch. A single 'start' screw would have a depth of thread commensurate with its pitch and in common usage this would be larger than a multi 'start' thread of equivalent outside diameter.

On the down side, as shown in Figure 1, multi 'start' threads have a helix angle which is far steeper than a single start thread. Since a shallow helix creates a 'wedge' action and uses the friction between the nut and screw to lock the two elements together, from Figure 1, the larger the lead, the lower the friction and hence, the less secure the fastening. Multi start threads are widely used to actuate mechanical devices from machine tools to conveyor systems. In these applications lower friction is not a problem.

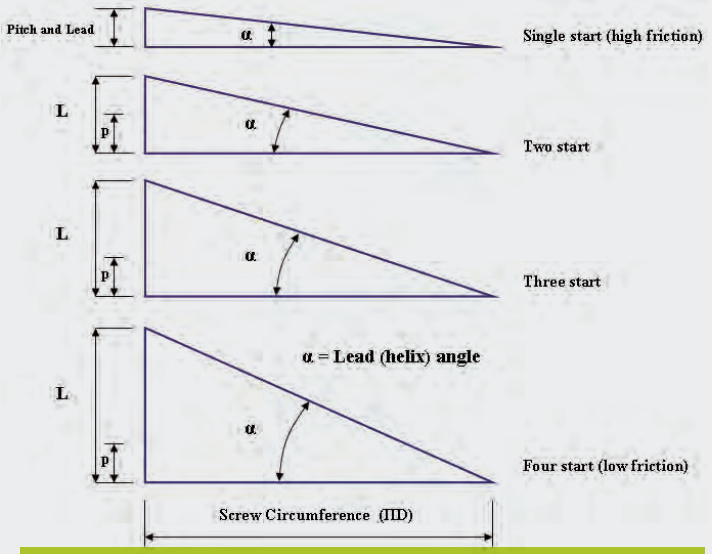

Figure 1. Relationship between Pitch and Lead.

In single element fasteners, for example, wood, self tapping screws and the like where the thread creates its own 'nut', the compressive nature of the material the screw is driven into the will create sufficient friction to hold a multi start thread. Of course in the construction industry, this will reduce the drive in fixing time by a half or two thirds etc.. The caps of many domestic polymer, glass and metal containers also have multi start threads making them quick to fill and fasten in an automated production cycle as well as in everyday use.

Interrupted Threads

Whilst a multi start thread will reduce the screw assembly time by the number of its 'starts' compared with a single 'start' thread, it will still require 'x' number of full rotations to achieve full tightening depending on the lead and the distance required to travel.

A way of reducing this is to use 'interrupted' threaded fasteners.

As can be seen in Figure 2, an interrupted thread is one in which a matching part of both the nut and screw are removed along the axis. This must be done in a balanced manner so the remaining portion of the thread of the screw can slide down the cut section of the nut. Once the axial relationship between the nut and screw has been obtained, the nut or screw is then tightened. However, it will be appreciated from Figure 2, that the axial distance over which an interrupted thread can be tightened can not be greater than the Lead divided by 2 times the number of slots. Two slots would give a maximum rotation of $\varpi/2$, three slots $\varpi/3$, four slots $\varpi/4$, etc..

Figure 2. Interrupted thread used on a military gun. [Image credit: public domain]

Like so many human inventions, interrupted threads were created to allow the rapid firing of breech loaded military guns way back in the 1840's. Figure 2 shows one such device making it quite apparent how much time could be saved in using an interrupted rather than a conventional thread.

Of course, the removal of part of the thread requires careful calculation as to the number of threads needed to ensure that the

design load is maintained within the safe working limits. Two design improvements have been made to increase the functionality of interrupted threads for breeches. These have been, the use of a circumferentially tapered thread which would 'lock' rotationally and the somewhat 'bizarre' Welin design of around 1890. This, as shown in Figure 3, has a number of different threads of increasing radius. It means only the thread with the largest radius need to have a slot cut to match it thus significantly increasing the threaded area.

This definition: $\frac{\text{number of steps}}{1 + \text{number of steps}}$ **× the length of the screw**

,simply means that for a two slot breech, the thread area would be 2/3rds an unslotted one, for three slots 3/4ths, four slots 4/5ths and so on. In functional terms, this strange design allows a shorter breech block to be used and thus provides an even quicker rate of fire.

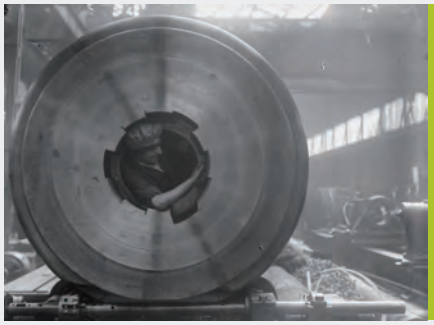

Figure 3. Worker cleaning the threads of a Welin breech on a 15 inch gun. [Image credit: public domain]

The Welin designed breech was common on large calibre USA and UK ordnance where national arms programmes could fund the complex manufacture and before the age of electronics deemed them largely obsolete. The question posed by this Author is, 'could the Welin concept be adopted for high volume and at low cost for common use today. If the answer is 'yes', then where?

For completeness, it should be noted that the suppliers of jig and fixture tooling elements have developed and market quick release swivel nuts and inclined screws. These are successful for what they are designed to do but would not be considered as options for the wider fastener market.

Tomorrow

Today, large volume manufacture of fasteners is needed to match the high volume assembly of everything from smart phones to long haul civil aircraft. Marketing strategies are required to make predictions on any 'new' model launch. Six months for top golf clubs, less than 2 years between facelifts for vehicles. Once the new model is launched, the old one is rapidly discounted and quickly erased from all but the used item websites and the interest of collectors of bygone ephemera.

As this Author suggested in the previously cited Fastener World Article, if the populations of China and India aspired to own 800 vehicles per 1000 head of population as do folks in the USA now, then the annual world output of vehicles would have to increase by 500%. Whilst the sentiment that all people should share equally is fine, the practicality for global resources would be a nightmare. Sustainability through reuse might be a solution where good design could allow products to be maintained, repaired, updated, recycled and reused without imposing greater strain on the Planet's resource base. Since fasteners hold the world in place, any long term planning to recast high volume manufacturing in a role based on sustainability must begin with the fastener industry. ■