Following the Thread

by Peter Standring

The technical issues related to thread fasteners are truly astonishing. They cover: design, materials use, abuse, testing, failure etc., etc.. National and international standards are used to define every aspect attempting to eliminate the problems which accompany all fastener development, manufacture and application.

The accelerating use of threaded fasteners for existing and newer applications means an inexorable growth of the industry. Many individualistic fastener types, created to solve a particular problem, have been bypassed by technical demand and/or fashion. However, for every hundred examples which have virtually disappeared, many thousand times more threaded fasteners have replaced them.

As mentioned in a previous article, **the enthusiastic take up of "Deproliferation" amongst fastener users will inevitably lead to ever larger volumes of fewer fastener types**[1]. It was this thought which led the Author to consider; if the wheel of progress comes full circle, how would we know where it started?

The Where

In the age of Genetics, the human ability to see, learn and copy, separates us from virtually all other life forms. That clearly is the reason for our dominant position within the food chain. Yet, many creatures are born and instinctively travel thousands of kilometres and return to breed on the same beach, in the same river or even in the same nest each year!

The Common Cuckoo bird, flies from Equatorial Africa to Europe, lays a camouflaged egg in the nest of another much smaller species yet is designed to look the same as its host. Then it flies away never seeing its offspring which, when it is fledged repeats what its parent did. At the present time we can only guess at how such information for survival is transferred and perhaps speculate how efficient the human learning process could be if we were born knowing what is needed for life.

Whilst the ability to learn from others is the key to forward progress, there must be an initial moment of knowledge creation which ensures that progress is made. Necessity being the Mother of Invention is a good way of putting it, which of course identifies 'need' as being the driving force behind knowledge creation.

Prior to the written word, ideas were transferred orally. This could only take place as and where people gathered collectively for mutual benefit and were able to communicate. The invention of writing naturally took place independently around the world, the first commonly agreed to be in the Middle East around five or six thousand years ago.

Information of a technical nature was invariably conveyed through depiction of situations as found on wall paintings, stone carvings etc.. A ramp or steps merely reflect the natural world of climbing a hill but a ladder which could be fixed or moveable, represents an intellectual development. Whilst it is still not known how they were constructed, it has been proposed that the Pyramids of Egypt could have been built by having a ramp spiralling up the outside. Intuitively, the effort required to climb a steep slope was understood by everyone who designed a defensive position. And for an attacker, a shallow slope would have made the effort that much less. Somewhere at sometime for a reason which has been lost in the mist of time, an individual realised that the Mechanical Advantage gained by moving up a gradual slope could also be obtained if the slope in question travelled round a cylinder. In this case, 'lateral thinking' became 'spiral thinking.'

Intriguingly, if you were to discover something, say an anti gravitational element, what would you call it? The use of the terms, Dark Energy and Dark Matter illustrate the problem. So, if someone in the very dim distant past invented a three dimensional spiral, possibly based on a rope coiled round a wooden pole as perhaps found on sail boats (a windlass)? What might they call it?

Archaeologist Stephanie Dalley, has suggested that the fabled Hanging Gardens of Babylon, might have existed in the Ancient city of Nineveh instead. These, she believes, were watered by a lifting screw device which the Assyrian Cuniform text describe as 'Almittu' some four hundred years before the invention of such a system was ascribed to Archimedes of Syracuse. The interesting thing is, that Dalley has identified the defronded trunk of the date palm tree as being an 'Almittu' since its removed fronds leave a spiral shaped vertical screw pattern along the trunk. Given no terminology for a 3D spiral existed, the inventor/users, adopted what was well known to them to describe the item.

The water lifting screw was being used in Egypt well before Archimedes who probably saw them operating there? What is perhaps more interesting is the fact that its invention should be attributed to an individual. Only for a brief period of less than 100 years did two independent research institutes exist simultaneously in the Mediterranean. One set up by King Hiero II in Syracuse, the other, 'The Museion' in Alexandria supported by the Greek Ptolemy Kings of Egypt. Both rulers offered the very best incomes and living conditions to the technicians and thinkers of the day to work for them to increase their powerbase through improved weaponry and technical progress. And it was only in these 'Silicon Valley' equivalents that individuals had inventions attributed to them. Both before and later, the creators of notable developments were rarely acknowledged, the achievements they made being claimed by those who ruled.

Somewhere and at sometime, the water carrying screw was replicated in what became a nut. This was perhaps not such a surprising development since the screw is capable of raising all manner of items carried in the water. It is interesting to speculate that a technically curious observer of a water carrying screw noted that the rotation of the screw also caused an individual item, say, a fruit, a leaf, maybe a lost shoe, to translate. So, by fashioning a 'female' equivalent to match the screw and then fixing that from translation, the screw itself would translate and of course, vice versa.

The Why

Moreover, as quickly as this curiosity had been produced and demonstrated, its true potential as a means of achieving a Mechanical Advantage would have become apparent. One of the first applications operating commercially, was found in olive and wine presses of the Greek and Roman world.

Many authors have glibly attributed the invention of the screw to a number of ancient Greek thinkers: Archytas of Tarentium, Philon of Byzantium, along with Archimedes, Hero and others. This is highly speculative given the fragments of documentary sources we have of them, all being from largely unprovable references by subsequent authors for whom there also exist only cursory accounts. In the other great ancient civilisations, China and India where the concept, development and use of screws would quickly have been recognised and adopted, there is little evidence. No evidence either of threaded fasteners has yet been found to show how the 2,200 year old Antykithera Solar Computer was held together. However, the design capabilities and skills of those who produced it (and very probably more than one), indicates that making screws to hold the wooden case and secure various items would have been a relatively simple task!

That the Mediterranean world used small screw fasteners in Roman times can be seen in Museums today in the form of medical 'speculum' (screw operated scissor/clamp devices), jewellery and many other artefacts.

In Europe, the non military use of screws for fastening did not become a design concept until around 800 years ago with the introduction of the weight driven mechanical clock. Unlike the progress normally made through warfare, the demand for time keeping came from the religious and merchant communities which used clocks to determine the times for their devotions and hours of employment. The passage of time had previously been marked by chanting and/or burning candles. Since the metalworkers also made the weapons and domestic utensils, it followed that the use of threaded fasteners would find applications wherever the cost of their manufacture permitted.

Tapered woodscrews being made from softer round iron, were formed between harder steel dies to provide the thread form. **Not having a pointed end, early wood screws required a hole into which they were screwed. Mechanical fasteners were either filed or sawn to produce a thread and this was used in plate metal to form a mating 'female' nut. In thicker metal, a smaller hole was drilled and the thread forced in by turning it to upset the 'female' form.**

Of course, the screw and its mating element were basically non interchangeable with other screws and were often tied together to ensure they were never lost when separated.

This situation became problematic once screws were being manufactured for guns. Screw plates which contained a number of various size screwed holes were used to make screws of a standard size and form and this satisfied the bespoke market. However, it was the need to obtain large numbers of 'identical' gun parts for large European armies of the 18th Century which led to the creation of the machine tools which could produce them.

The How

In 1750 Antoine Thiout of France was the first known user of a leadscrew on a lathe. This was used to cut individual screws and mating nuts. **The first Industrial Revolution in Britain dramatically increased the demand for threaded fasteners and brought about a need for machine tools which could produce them.** Primary amongst these was Maudslay who in 1797 produced an 'all metal screw-turning lathe' for making precision parts. In 1810 he adapted a 'leadscrew' to a lathe which he then produced commercially. Interestingly, all machine tool of this period used threaded fasteners to hold the various elements of their construction together.

Following the explosion of manufacture which took place in Europe and the USA in the early decades of the 19th Century, a multitude of different threaded fasteners were devised for use on large steam plant through to scientific equipment. In the UK, Whitworth who was a leading figure in the burgeoning machine tool industry, travelled widely to secure examples of as many different types of fastener thread forms he could find. He then set about working to find which he thought was the best. Interestingly, he determined that a 55° inclined angle was preferred (many years earlier Lowenhertz working in Prussia had proposed an angle of 53° 45' to attempt to make the strength of the male screw equivalent to that of the female nut).

Whitworth's work resulted in defining the British Standard Whitworth (BSW) thread which continued in use into the 1960/70's prior to metrication.

The advent of WWI instantly created the need for interchangeability of screwed parts across national boundaries. Not only could equipment not be shared or repaired, the manufacturing industries of the different countries involved required education in the thread systems of other nations along with the means to make and measure them.

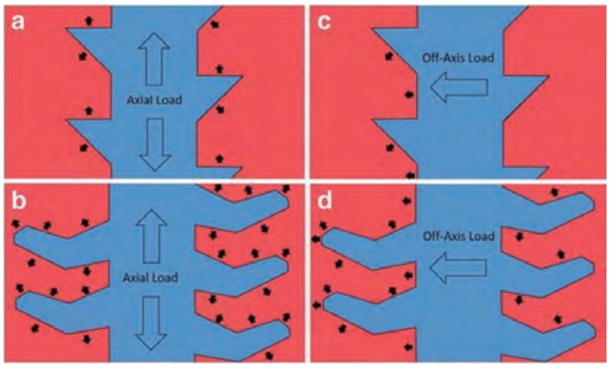

Figure 1. Comparison of load vectors on the threads of the new Bone-Screw-Fastener compared to the conventional buttress thread resulting from an axial loading force (a, b) and from an off-axis loading force (c, d)

This progress is continuing today driven largely by the globalisation of industry and the markets they serve.

Rationalisation and standardisation of both national and international threaded fasteners has brought us to where we are now. It is astonishing to note the scale of the ISO Fastener Committee in its work to standardise the metric fastener systems (https://www.iso.org/committee/45446.html). Couple that with the individual national standards together with the specialist sectors of automotive, aerospace etc., including orthodontal and orthopaedic and it is hugely substantial. None of the factors which influence screw selection have changed since a clever person first hand fitted a nut to a screw thread.

Material, environment, application, design; they all must have played a part in realising the first practical working device. But the development from that example has always been to introduce improvements most of which have been driven by in service failure and/or cost. Today, for every aspect of functional requirement, there are standards stating how these can and must be achieved together with methods to test that they have. For most screws, the head design is standard in order to accommodate general use. However, specialist security application head designs are such that they can only be torqued one way. In some high cost smart phones, the sixty plus screws have head cavities for which only the manufacturer has the correct geometry sockets ensuring even more profit is made from repairs.

Despite this plethora of specification, engineers are still designing new thread geometries. These, as in the case of Figure 1 for application into human bone, are believed to offer answers to the problems of 'pull out' given the strength of bone is a small fraction of that of metal [(2)].

An interesting suggestion for forming threads in a press was proposed by Gensert at a conference in 2009[(3)]. The simple idea which the author questioned why it had not been thought of before, was to use a segmented die to close laterally around a workpiece. **The die elements two, three or more have the desired thread and/or other form which they impress in the body of the workpiece. The key to the process lies in the preform having shallow grooves located in the area where the die segments meet. These are designed to accommodate any excess material displaced during the forming operation. The technique, it is claimed, is ideally suited to producing hollow fasteners having conventional thread forms and other features, for example knurls, in a single, lap free operation.**

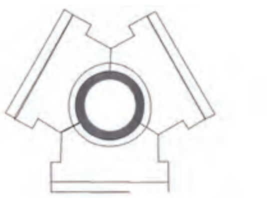

Figure 2 (i) Thread forming on hollow components

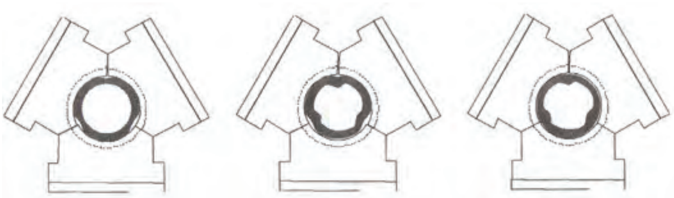

Figure 2(ii) Blank variations on hollow components

Tomorrow?

So, what can we say has happened on the 2700 year journey from Nineveh? Perhaps 500 years between the water screw and the mating nut? Another 500 years of screw and nut before the concept was lost for around 1000 years. Then another 300 years before the technical need for the thread was grasped and a further 300 years before means for its mass production were developed?

Today, literally countless numbers of threaded fasteners are produced worldwide, most of which fully comply with the thousands of pages of documentation defining how they should be made and assessed. Standardisation becomes essential in reducing costs where brand names are competitive, where they are not, non standardisation is used to enhance profit margins. And tomorrow? Change in technology is only one facet of market disruption. The 'what ifs' include: Creative Thinking (the 500 years before a 'nut' was conceived)? Market Demand (used only in special cases – 500 years of Greece and Rome)? Lack of Knowledge (1000 years – European Dark Age)? Unavailable Technology (600 years of 'Craft' output)?

The ability to communicate started the whole human story moving. In every part of the World satellites make on-line communication possible and over 30% of the population use it for social media. Standardisation will reduce costs but environmental issues are likely to determine the direction technology takes.

An easy guess is 'electrification' powered by wind and solar energy in sufficient quantities to make all other sources unnecessary?

Online retailing for all needs being met by algorithm controlled factories which deliver direct to the retailer and next day to its hub and the customer?

Social Malls where entertainments are laid on by manufacturers to 'invite' folks to view the latest goods which they can then purchase online?

Harmonisation programmes to ensure that all people can have the lifestyle which best suits them? And the fastener industry?

As always, like the thing which holds up the trousers, fasteners will need to change to suit the fashion. But they will always be needed, that is, unless we choose to dispense with clothes! ■

References

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