The Manufacture of Screws

The concept of the screw, both as a fastener and as a device to move material, has been known since ancient Greek times. Not until the age of mechanization, though, were screws produced with enough precision and in sufficient quantities to become crucial components of the development of technology.

Screws can be made of iron, steel, copper, bronze, brass, aluminum, wood, or hard plastics. Mechanically, a screw is a continuous inclined plane wrapped around a cylinder.

Several names are often mentioned in connection with the invention of the screw. The Pythagorean philosopher Archytas of Tarentum is alleged to be the actual inventor of the screw in the fifth century B.C., though the date of the screw's first appearance as a useful mechanical object is not clear.

Archimedes (third century B.C.) is often credited with the invention of the water screw, or "screw of Archimedes," though similar devices appear to have been used for irrigation in Egypt much earlier than this.

The Greek scientist Hero, living in Alexandria in the first century A.D., invented a screw press for squeezing olives and grapes to produce olive oil and wine. Turning the shaft of the screw press applied great and constant pressure to the fruit, producing much more liquid than other simple crush presses could. The Romans used the screw press for pressing clothes. A drawing of such a clothes press survived in the ruins of Pompeii from 79 A.D.

External screw threads could be made by tediously marking the diagonal channels on a wooden rod, then sawing, and finishing by filing. But cutting the *internal* thread of a nut or a pipe proved to be problematic. By the first century A.D., taps for cutting or grinding internal threads were also in use.

Many centuries later, as technology advanced into the age of mechanization, screws took a more prominent role. For instance, England's large Salisbury clock (made in 1380, and perhaps the oldest clock still operating in the world) was constructed without a single screw; craftsmen used wedges or rivets to hold its iron frame together. The delicate pieces of smaller precision clocks created in later years, though, could not obviously be hammered together, but required small metal screws for assembly.

Metal screws and nuts came into use in the 15th century. A hexagonal or square head was turned with a box wrench. A century later, the screws used in armor featured nicks or slots in their round heads, possibly for the use of a screwdriver. Centuries later, James Watt (1736–1819), best known for his invention of the practical steam engine, also designed a screw printing press: A letter written in special ink was screwed up against moist copy sheets for reproduction.

In his notebooks, Leonardo da Vinci (1452–1519) sketched a machine for cutting screws as well as a screw-operated printing press.

The wood screw, which deforms the wood itself into accompanying nut threads, is not mentioned until the mid-16th century. A different variation, the metal screw, is designed to hold sheets of metal that are thinner than one groove, which obviates the need for making threads inside the material.

A mid-16th century mining treatise offhandedly describes a large slot-head screw tapering to a point (for boring into rock), as if it were a common object. But not until the mid-19th century were screws commonly made with pointed ends. Before this time, a hole long enough to accept the full length of the screw was required. An American traveler, George Escol Sellers, took a trip to Britain with instructions from his father "to see and learn all that was accessible in the way of civil and mechanical engineering." Sellers toured many renowned British factories, but he wrote with some amusement how those he encountered resisted the American idea of adding points to screws:

"Mr. E.R. Sheer, a pianoforte maker of Philadelphia, in fitting work where wood screws had to be withdrawn and again driven in the same holes had found it difficult to make the common square-end English wood screw enter and follow the thread cut by the first insertion...with file and chasing tool he tapered the end of the screw like that of a gimlet. He had given me several of these as samples, with the request that when in Birmingham I would induce some good screwmaker to fill a considerable order of gimlet-pointed screws. I had gone to the makers...[but] failed to induce any of them to fill the order; they and their predecessors had always made wood screws as they were then doing, and they would have nothing to do with such new-fangled notions."

Typically, each screw manufacturer designed the screw threads to his own convenience. Threads cut with a sharp V profile had disadvantages because the weak, pointed crests broke off in small pieces and high stress concentration in the sharp root often caused the screw to fail—resulting in inconvenience, delay, and expense because it was difficult to find a replacement screw that would fit the grooves.

In 1841 Sir Joseph Whitworth in England proposed that all screw manufacturers use a rounded fastening thread with grooves tilted at 55°; this became the British standard thread used for general engineering. In 1864 William Sellers (no relation to George Sellers, mentioned previously) in the United States proposed a screw with a 60° thread, with crests cut off and roots filled in, which was accepted as the U.S. standard. In 1948 the United Kingdom, United States, and Canada together adopted the Sellers standard.

Screws are mass-produced by turning on a special lathe, where the threads are cut with a single-point cutting tool. Dies for cutting threads, as in pipes, are made with internal cutting edges of the proper size, shape, and pitch.

Milling is useful for producing large and accurate threads. Rolling a screw blank between flat or cylindrical dies allows a high rate of production; this method was introduced for manufacturing cheap stove bolts, but improvements have made possible the high-volume production of superior screws and bolts.

Today, modern machines create billions of screws and bolts each year. These machines are essentially automatic turret lathes with one or more spindles; each component of the multiple-tool holder is brought into action on a pivot as the manufacturing steps proceed: turning and threading bar stock, forming the head, and cutting off the screw or bolt. Special screws can be manufactured by using chasers or comb tools controlled by master screws.

Few simple ideas have had so great an impact on the development of human civilization.

KEVIN J. ANDERSON

FOR FURTHER READING, consult *Nuts and Bolts of the Past: A History of American Technology, 1776-1860*, by David Freeman Hawke, Harper & Row, 1988; and *The Discoverers* by Daniel J. Boorstin, Random House, 1983.