Screw Manufacturers Embrace Thread Whirling

The increasing demand for bone screws, implants, and other microcomponents creates a need for new techniques that produce specific thread forms quickly and with high tolerances. Human bone has a hard outer shell and a softer, almost sponge-like core. As a result, bone screws need to be hard and sharp enough to penetrate the outer shell, but the thread form must resist separating from the soft core. To stay competitive, manufacturers change their thread profiles every two to three years, and with each profile might come four different screw designs. A bone screw can be as unique as the human bone it penetrates, and in some cases is designed personally by an orthopedic surgeon for his/her patient.

Generally, bone screws tend to have a high aspect ratio (screws are much longer than their diameter), making their manufacture with a traditional single-point threading tool problematic because the screw tends to bend during cut. With single-point threading tools, special support devices are needed for the screws. In addition, bone screws have deep threads, so many short cuts must be made, which is a slow process that leads to shorter tool life. Finally, finishing steps are typically required.

The other fundamental limitation associated with using a single threading cutter for machining bone screws is the limited helix angle of only 7°. Modern bone screws are designed with helix angles up to 20°.

As a result of these drawbacks, the medical industry has begun shifting from single-point threading tools to thread whirling. Thread whirling is a type of thread-milling process in which the cutter edges of the tool reside on the outside. The entire threading operation is performed in a single pass from bar stock, typically using a thread-whirling attachment on a sliding head machine.

A thread-whirling attachment consists of the ring (holder) and inserts.

Other steps in the screw manufacturing process—turning of the front and back of the screw head, drilling of the head, and clearance turning of the hole bottom—are also performed using the thread-whirling attachment.

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Most machinists use a CNC Swiss-style lathe for thread whirling. The Swiss-type turning centers are well suited for this task because the cutting point is close to the guide bushing for increased support for long-length-to-diameter screws. The shorter distance between the cutter and guide bush also minimizes vibration during the cutting operation. Swiss-type lathes have the precision and repeatability needed for a variety of medical tooling applications including thread whirling. The thread-whirling ring is simply mounted onto the spindle. For very high-volume bone screw production, an alternative to using a thread-whirling attachment on a Swiss-style lathe is a dedicated thread-whirling tool.

One of the biggest potential problems in thread whirling is chatter. Inserts with differential pitch allow chatter to become a non-issue, significantly extending tool life.

For standard threads, inserts are designed to create HA and HB thread forms, with the specific dimensions and tolerances spelled out in ISO 5835-1991 for medical screws.

During whirling, the workpiece rotates slowly while the tool rotates at very high speed in the same direction. The thread pitch dictates the tool rotation rate and the bar feed rate. The helix angle (up to 25°) is set by the angle of the cutter ring relative to the workpiece. The ring is positioned slightly off-center from the part so that a single insert engages the workpiece per rotation. Each insert is designed specifically to achieve a desired thread profile when cutting a specific material.

Thread whirling creates well-defined chips on materials that are normally difficult to machine, such as 316L VN stainless steel, titanium or cobalt chrome, common materials used in bone screws. Generally speaking, titanium, with its properties of very light weight, high strength and biocompatibility, is used in bone screws that will remain in the body, while stainless steel is used in screws that the surgeon will later remove.

Thread whirling uses a tangential cutter path and its increased rigidity means that surface finish is improved and burrs are minimized due to reduced chip load, for increased tool life. With thread whirling, finished surface quality equals or surpasses that of a grinding process.