A SUCCESS STORY: 
LOW-DEFORMATION WORKPIECE CLAMPING

Before an optimum clamping solution can be defined, many requirements of the workpieces, type, machine frequency, and process-change integration must be properly addressed.

By Steve Hartung

Those who want to turn, mill, or grind rings, flanges, housings, or other thin-walled parts will quickly reach the limits of what is possible using conventional lathe chucks or face plates: The parts are deformed during the clamping process; shaping and geometric tolerances are difficult to keep to, and the interfering contours of the clamping devices restrict the accessibility. There are a great deal of alternatives here—from the compensating multi-jaw chucks, the magnetic clamping technology, right up to the pendulum jaws. In order to ensure that things run smoothly, it is worth knowing the strengths of the individual problem solvers, because this saves time, money, and often nerves.

As is so often the case for low-deformation workpiece clamping, there is no one-size-fits-all solution. The requirements of the workpieces, type, and frequency of the machining as well as the integration into the process change vary so severely that an individual observation at the user level is always worthwhile. The following questions are primarily important here:

- What parts are to be machined in what batch sizes?
- How flexible must the machine be able to be used?
- What shape and position tolerances must be adhered to?
- How will the parts spectrum develop in the future?

Only when these and other aspects have been clarified the optimum clamping solution can be defined.

PENDULUM JAWS MULTIPLY THE NUMBER OF CONTACT POINTS

For pendulum jaws, users take advantage of the number of clamping points in order to minimize deformations on the workpiece. This way, with identical clamping force and a doubling of the clamping points, the achievable roundness accuracy increases in practice by a factor of 10. Usually, pendulum jaws are made of a movable mounted pendulum body with two clamping inserts, which are mounted on a supporting jaw with the aid of a bearing bolt. For demanding applications, there may be four or six clamping inserts, either soft or case-hardened. As pendulum jaws are mounted like one-piece top jaws, a conventional 3-jaw chuck can be converted into a 6-point clamping in no time. As the jaws are adjusted to the workpiece, they can compensate for form tolerances within a certain range, for instance, with cast bodies.

It is beneficial if such pendulum jaws can be fixed for finish machining or for clamping pre-turned surfaces. Furthermore, the jaws should be as light as possible so
as to achieve faster speeds. Calculation programs can be used for calculating what compensation is required for achieving specified concentricity tolerances. Primarily for small tolerances, experience pays off, because with matured special solutions, enormous effects can be attained. But there are also restrictions: Pendulum jaws are comparably expensive; they wear out easily, and they are sometimes quite heavy and restricted when it comes to flexibility.

COMPENSATION JAW WITH CENTRIFUGAL FORCE AND VIBRATION COMPENSATION
Hydraulic compensation jaws set a new benchmark for low-deformation workpiece clamping. They combine a balancing workpiece clamping with centrifugal force compensation, vibration-damping characteristics and micron-precise concentricity. The integrated oil chamber system is a central feature, above which two or more oscillating clamping elements for clamping rough or finished parts are mounted. As they individually adapt to the workpiece, form tolerances of cast bodies, for example, are reliably compensated. Compared to conventional 3-point clamping, the number of clamping points is increased, which also lowers the deformation of the workpiece and the obtainable roundness is significantly increased.

At high speeds, the hydraulic clamping system automatically ensures centrifugal force compensation so the clamping force is always reliably maintained. In order to minimize workpiece deformation, the clamping force can be considerably reduced in comparison with previous solutions without restrictions on process reliability. For maximum precision on the component, the concentricity also can be adjusted micron-precisely on the chuck jaws. Additionally, the vibration-damping characteristics of the oil-chamber system result in a better surface quality of the workpiece and the tool life. Hydraulic compensation jaws are suitable for low-deformation OD clamping of rough and finished parts and are available for all lathe chuck sizes and serration types.

COMPOSITE JAWS ARE THE MOST COST-EFFECTIVE ALTERNATIVE
Special jaws made of fiberglass composite are an often underestimated problem solver. Their high coefficient of friction of 0.3 to 0.4, as well as a large angle of wrap ensure that high machining forces can be transmitted even with low clamping forces. Here, the support structure of the aluminum supporting jaw ensures stability. As a result of the low weight, only low jaw centrifugal forces are created during turning operations. As a result, plastic jaws are also suitable for high machining speeds up to 6,000 rpm. In addition, they do not leave

Hybrid chucks combine a classic centering chuck and a round magnetic chuck. They center the workpieces and clamp them without any deformations. (Courtesy: SCHUNK)
Magnetic chucks with electrically activated permanent magnets are a real set-up time killer for low-deformation workpiece clamping. These are used in different versions for low-deformation workpiece clamping. Compared to a conventional set-up in the 3-jaw chuck, a 6-point pendulum improves the calculated run-out accuracy by a factor of 17. (Courtesy: SCHUNK)

**OSCILLATING MOUNTED 6-JAW CHUCK ENSURES HIGH REPEAT ACCURACY**

The smaller the tolerances on the workpiece, the higher the required repeat accuracy; the more speaks in favor of oscillating balancing 6-jaw chucks. They consist of a central chuck piston carrying three inner pendulums aligned at 120 degrees. Each pendulum is connected to two base jaws. This ensures workpiece centering between six contact points, which can be adjusted in pairs. As the clamping forces are directed towards the chuck center, optimal centering is achieved without distortion of the workpiece even for raw parts.

Workpieces are aligned and clamped in the 6-jaw chucks in no time. The chucks are perfectly adapted to the raw part with their oscillating jaws. For finish machining or for clamping pre-turned surfaces, the pendulums can be clamped similar to the pendulum jaws in the center positions, meaning all six jaws can move concentrically. Because of its high precision, it is possible to eliminate entire production steps, for example, by reaching tolerances during the finishing process that would otherwise only be reached in complex grinding operations.

**RADIAL POLE TECHNOLOGY FOR INTERFERING CONTOUR-FREE MACHINING**

Magnetic chucks with electrically activated permanent magnets are a real set-up time killer for low-deformation workpiece clamping. The most common are radial pole plates for which the magnetic elements are arranged radially around the center. With them, bearing rings, for instance, can be machined in a single set-up on the outer and inner diameter and on the front side. As the magnetic field acts into the outermost peripheral zone, even large workpieces are clamped securely and without any deformations. Due to the two-dimensional holding force, the machining takes place largely without any vibrations. This protects the cutting edges of the tools and improves the quality of the workpiece surface. To align the workpieces, the holding force can be adjusted using the control system or the holding force regulation. In order to ensure optimum stability, radial pole plates up to a diameter of 4,000 mm should be produced from a single piece. For larger plate diameters, plates in segmental design may be advantageous as these can be transported more easily. To suit the respective application, there are standardized radial pole plates in three versions: for grinding operations, as an AlNiCo single magnet system; for turning operations, as an AlNiCo double magnet system with high holding forces; and finally, for demanding volume machining with milling and turning as an extra strong AlNiCo neodymium magnet system.

**SQUARE POLE TECHNOLOGY INCREASES FLEXIBILITY**

Users wishing to act flexibly on mill/turn centers combine magnetic chucks with square pole technology with an efficient pair: They use the magnetic chucks both on top for clamping workpieces and downward for flexibly placing the clamping solution on the machine table. Such a solution can be set up and loaded with a workpiece in just a few minutes. Here, variable pole extensions ensure a safe and, at the same time, deformation-free workpiece clamping.

Without additional set-up effort, workpieces of varying sizes can be machined alternately with a high level of precision on the quadratic pole plates from three or five sides. With the aid of a multi-level holding force control system, the parts can be aligned within seconds and clamped without any deformations by means of a short current pulse. Like with the radial pole plates, no additional energy feeding is required for square pole technology after having activated the permanent mag-
HYBRID CHUCKS COMBINE RADIAL POLE TECHNOLOGY AND A CENTERING CHUCK

The peaks of the low-deformation workpiece clamping are formed by hybrid chucks, for which the technology of a classic 3- or 6-jaw centering chuck is combined with the technology of a radial pole plate. The clamping process is designed extremely easily: The workpiece can be manually inserted into the chuck, which will be centered by three chuck jaws, and then securely clamped by electropermanent magnets.

Particularly for large rings, it is worthwhile that vibrations are eliminated, which has an effect both on the workpiece quality and the tool costs. The parts are simply pre-roughed. Then the magnet is temporarily deactivated in order to release workpiece warpings, and then the part can be finish turned. The hybrid chucks can also be activated at varying power levels. They are suitable for use on revolving lathes, mill/turn machines, vertical pick-up lathes and special machines.

ABOUT THE AUTHOR

Steve Hartung is rotating workholding group manager. He has worked for SCHUNK for 18 years, where he manages the rotating workholding team in the U.S.