

Benefits of Swiss Screw Machining for High-Precision Manufacturing

Impro

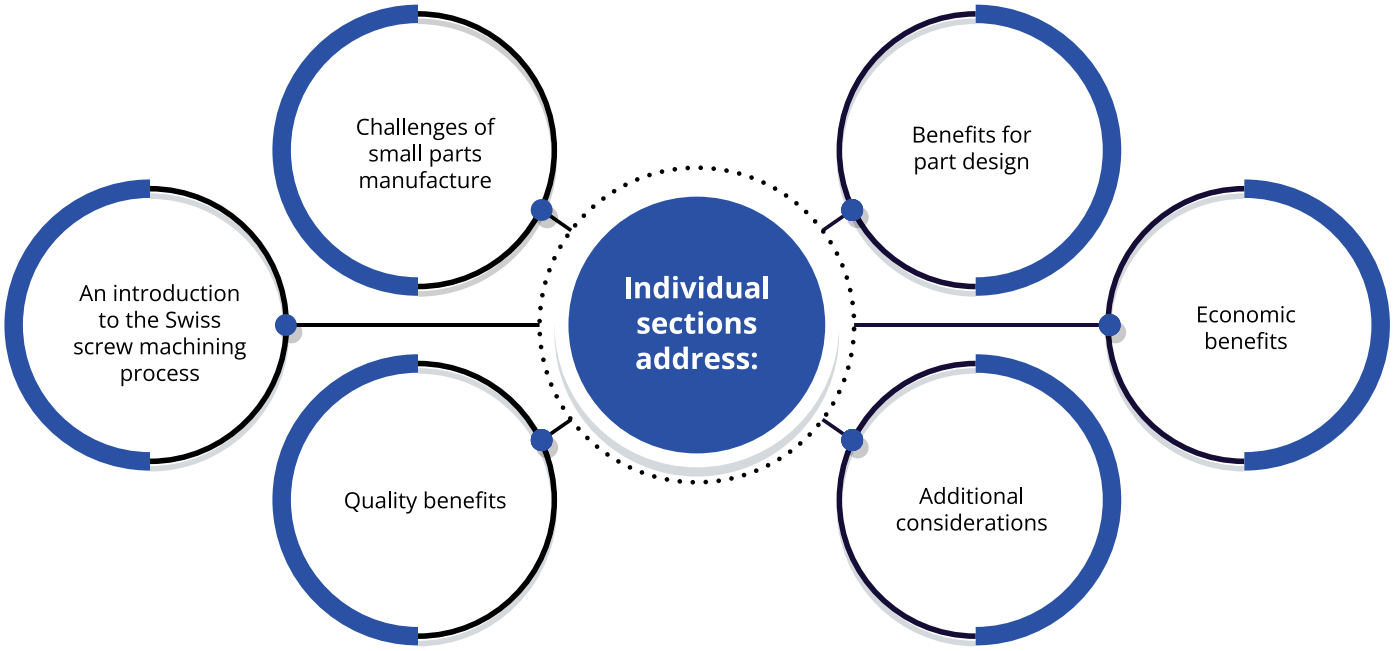
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Small, high-precision metal parts are essential components of equipment used in almost every industry. Hydraulic systems, fuel injection systems, medical devices and machinery all rely on pins, rods, shafts, spools and couplings, and the best way of making these in quantity is by Swiss screw machining.

As precision machining specialists, Impro maintains extensive Swiss screw machining capabilities. This eBook provides an introduction to Swiss machining and explains the benefits of using this technology to produce high-precision metal parts. Individual sections address:



CHALLENGES OF SMALL PARTS MANUFACTURE

Many types of mechanisms use components with intricate designs. They transmit motion, prevent motion, hold other parts in position, and form linkages and locking mechanisms. Fluid handling systems use complex small parts too. Connectors, flow regulators, valves and valve spools are just some of the high-precision parts used.



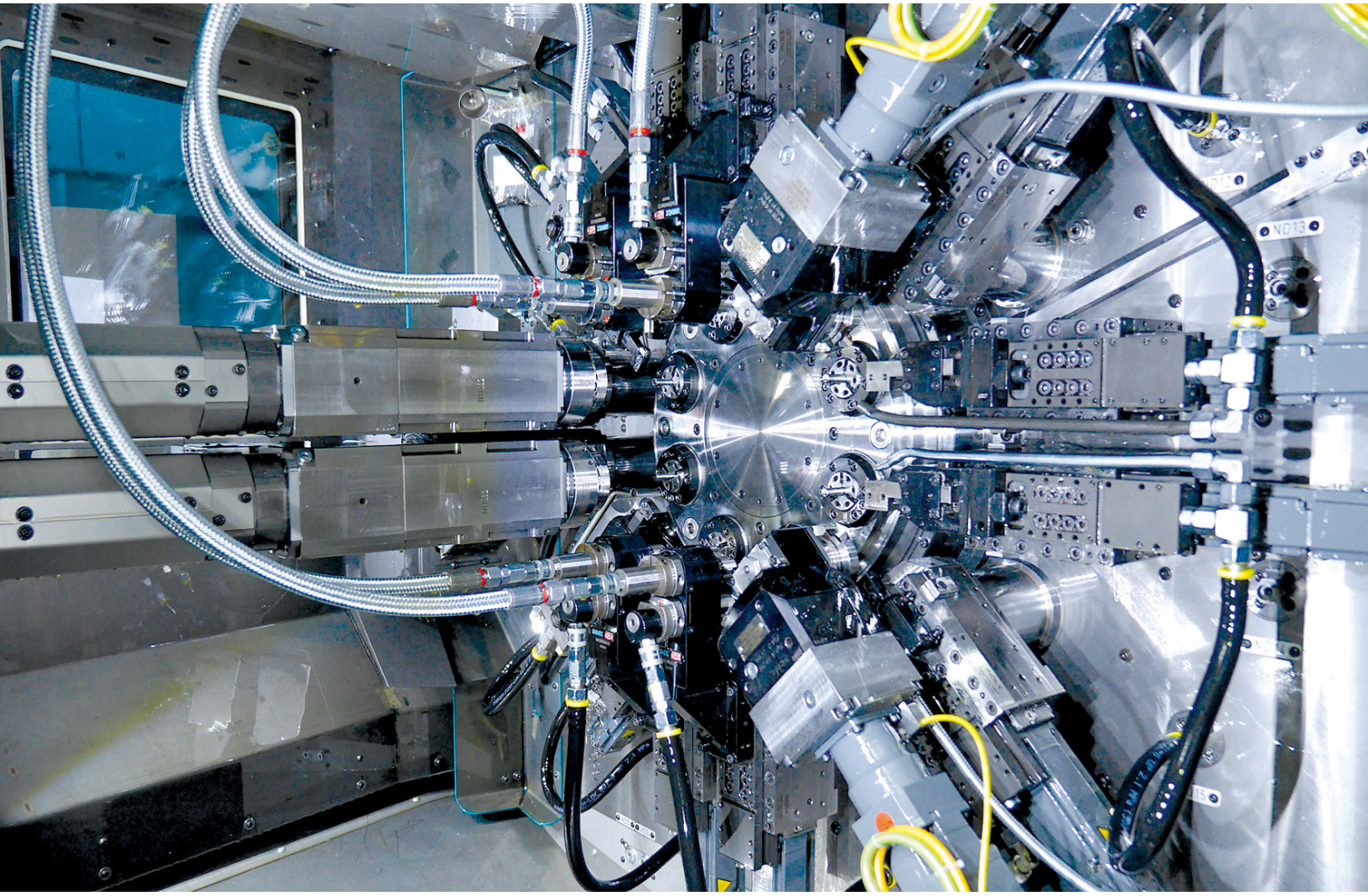
Small parts usually have small features and are made to very tight tolerances. Producing these on conventional CNC lathes and milling machines is difficult, the main reasons being:

- **Lack of surfaces on which to grip or locate** – machined surfaces can be marked and may deform under high clamping loads
- **Insufficient space for cutting tool access** – stiff tools need substantial support to prevent deflection and chatter
- **Inability to achieve the surface speeds needed for metal cutting** – small diameters need faster rotation than most lathes can achieve
- **Inability to maintain the tight tolerances needed** – conventional turning and milling are seldom better than +/- 0.001” (0.025mm)
- **Poor process economics** – more time is spent on loading, unloading and positioning than on cutting metal

When any or all of these arise, Swiss screw machining presents an alternative.

AN INTRODUCTION TO THE SWISS SCREW MACHINING PROCESS

Swiss screw machining is essentially a turning process, but with powered tools on slides providing the ability to do some milling. Unlike a standard CNC lathe, a Swiss machine has six or eight spindles arranged horizontally in a drum. The process was developed by the Swiss watch industry for producing the extremely smaller fasteners needed in those assemblies. Today it's more generally referred to as "Swiss machining".



Each spindle is loaded with bar stock from the side of the machine (or the back, if facing the spindles end-on). This arrangement makes it possible to perform multiple machining operations on a single machine. For many part geometries it's possible to produce the part completely on this one type of machine.

In operation the entire drum indexes from one spindle position to the next. At each position there are one or two cross slides. These can hold standard cutting inserts for turning diameters, chamfers and grooves, or they can be fitted with powered tools like drill bits and small end or ball mills. After locking the bar in position these are used to drill cross holes or mill flats and other features.

To turn down diameters, the machine pushes the bar stock forwards in the Z direction. This is one of the big differences between Swiss machining and conventional turning where the cutting tool is moved along the workpiece axis.

Some Swiss machines are equipped with a secondary or subspindle that grips the part as it's parted-off from the bar. This enables secondary finishing operations not possible in bar form. The spindle can also be used for on-axis drilling into the bar.



QUALITY BENEFITS

Swiss machining is capable of holding tighter tolerances than achievable by conventional CNC turning. Specifically, it provides better:

- Straightness
- Concentricity
- Linear and diametric tolerance adherence
- Burr elimination
- Surface finish

Superior straightness results from the way in which the bar is held in the drum. A collet mechanism grips the bar, turning it and feeding it through a guide bushing into the cutting zone. This bushing, coupled with the use of a machining strategy called segmented machining, reduces bar deflection.

Segmented machining refers to not having the whole length of the part being machined protruding from the bushing. As parts that go through Swiss machining typically have a large length to diameter aspect ratio, even small lateral cutting forces cause considerable deflection. To prevent this, only a short length of bar is pushed out from the bushing. This is machined complete before another length is pushed out. This “segmented” approach continues until the whole outside diameter has been turned completely.

Concentricity is better than when diameters are produced in successive machine setups. The collet and guide bushing never release the workpiece until machining is complete, so the centerline remains unchanged throughout the process.

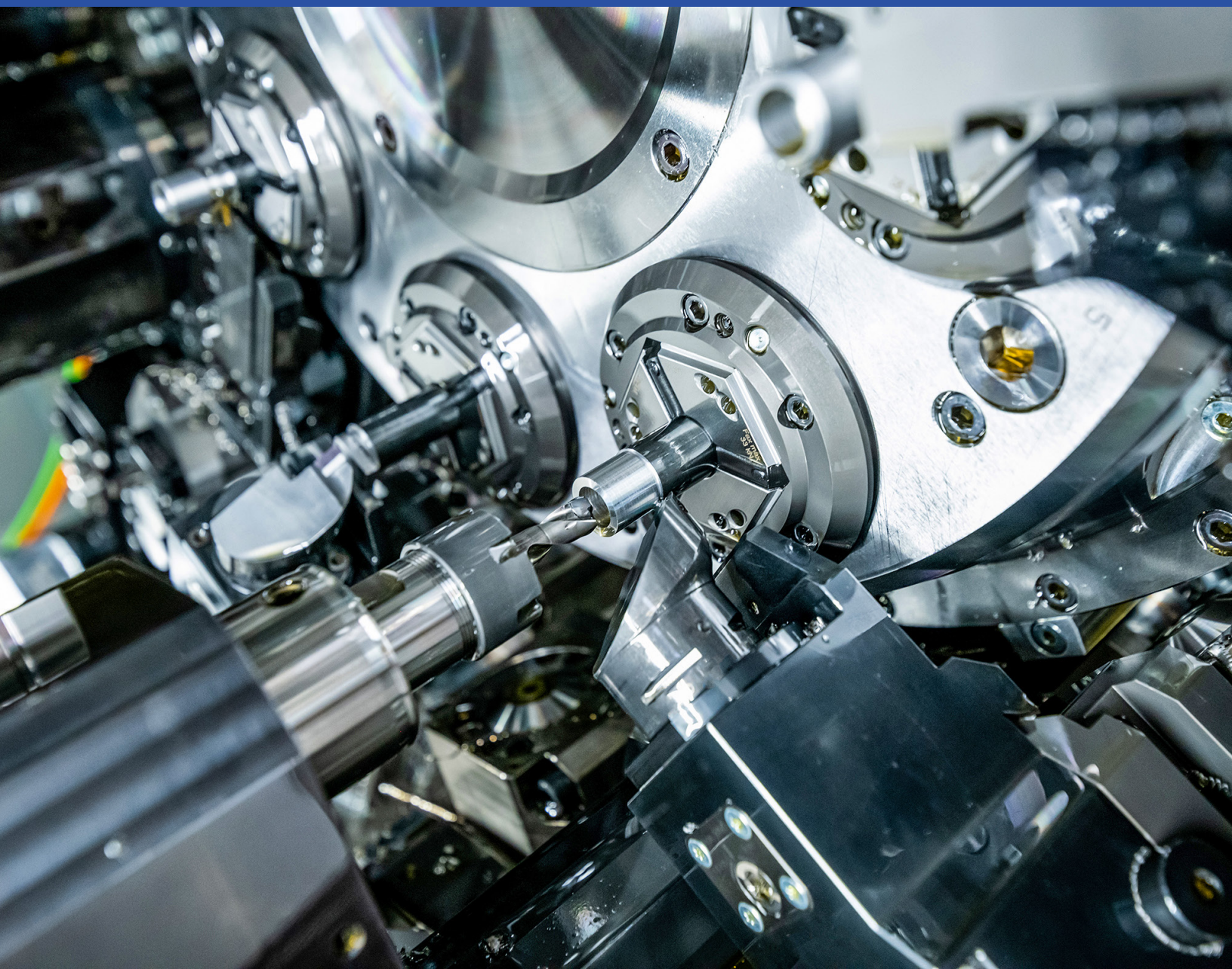


Swiss turning holds tighter tolerances than larger single spindle lathes can maintain. This stems from the way in which Z-axis movement is produced by the collet rather than separate slides.

Collet, drum and machine rigidity combine to ensure very good surface finishes are achieved. In addition, Swiss machines can run at higher rpms than most lathes, which allows slower feed rates for smoother finishes.

A third surface finish factor is that large cutting tool radii are preferred. This is to minimize defection and improve straightness, but it also yields a better finish.

An eight spindle Swiss machine might have 16 tool stations. If part geometry doesn't need all these to be utilized, they can be configured for burr removal. This might be countersinking cross-drilled holes or by using abrasive tools or brushes.



BENEFITS FOR PART DESIGN

Swiss machining can be performed on ferrous, non-ferrous and nonmetallic materials. It's particularly advantageous on long, thin parts that would deflect on a single spindle lathe.



With its ability to produce complex features, Swiss machining lets designers combine what would otherwise be separate pieces into a single item. This reduces assembly work and simplifies production planning and control through lower piece counts.

With lower cutting forces, (to reduce deflection), Swiss machining enables use of smaller and thinner cutting tools. This permits production of features as small as 0.0003" (0.0075mm) and diameters of 0.003" (0.075mm).

ECONOMIC BENEFITS

Swiss machining is an efficient way of producing smaller, high-precision parts, particularly in high quantities. This stems from:



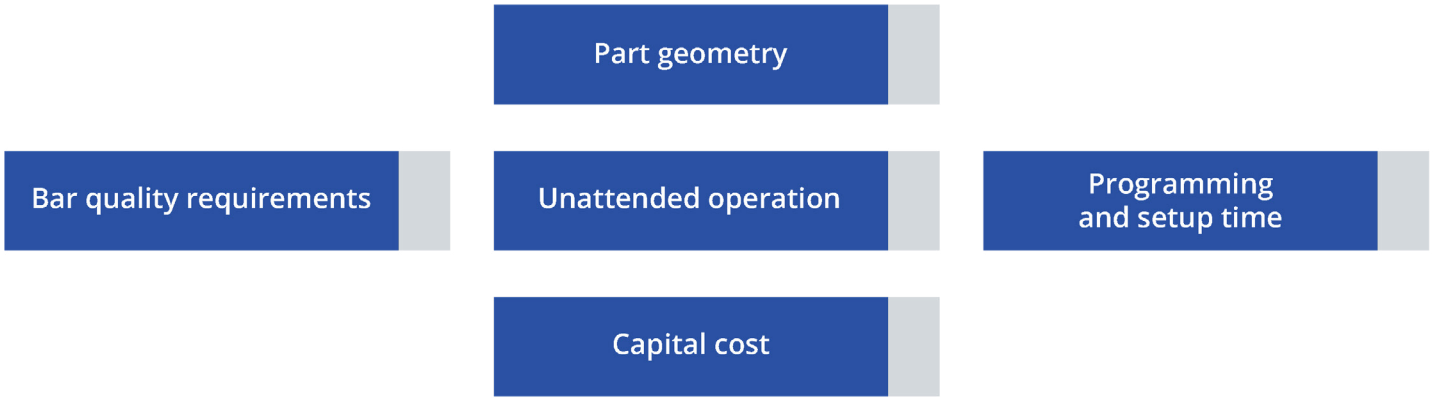
Many parts can be machined completely in one go on a Swiss machine. This eliminates secondary operations, saves on handling, eliminates the potential for part damage in transit and storage, and reduces inventory.

The bar feed process minimizes offcuts and waste, so maximizing material utilization. Labor costs are very low because these machines run virtually unattended.



ADDITIONAL CONSIDERATIONS

While Swiss machining is advantageous for producing high-precision parts, it is not a panacea. Limitations to be aware of include:



The largest bar diameter the Swiss machines at Impro can handle is 1.25” (32mm). However, maximum part length is up to 24” (600mm).

As collets grip the bar material, this must be very straight and round. (Non-round bar will produce non-round parts.) For this reason ground bar is usually specified with limits of +/-0.0002” (0.005mm). It is more expensive but results in better quality and avoids unplanned stoppages.

Unattended operation requires close attention to chipbreaking practices during turning, especially on softer, more ductile materials and those like titanium that are “gummy”. If long stringy chips are allowed to develop they can jam the machine and damage workpieces. In extreme cases they can even pose a fire risk.



The complexity of these machines makes them harder to program and increases setup time. To recoup these costs, longer runs of high quantity orders are preferred.

Swiss machines are significantly more expensive to buy than single spindle CNC lathes. This cost is more than recovered by their superior productivity but it does mean they should be highly utilized.

YOUR PARTNER FOR HIGH-PRECISION MANUFACTURING

For producing the high-precision metal parts needed in many assemblies and types of equipment, Swiss screw machining is often the preferred method. It's fast, accurate and very cost-effective, for the right order quantities and part geometries.

Machining specialists at Impro have extensive experience of this type of metal cutting process. If you need a source for high-precision metal parts, Swiss machining may be the way to go. Contact us to discuss your requirements.

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