Cold Headed vs Machined Solid Pins

SPIROL WHITE PAPER

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Solid Pins are common fasteners used for aligning, joining, and assembling multiple components. Solid Pins are most useful where the clamp load of a bolt is not needed. They are also used for specific functions such as locating components, hinges, tamper-resistant designs, etc.

Two common manufacturing methods used to produce Solid Pins are cold heading and machining. Cold heading and machining both produce high quality, consistent parts. Interestingly, many outside diameter (OD) ground dowels are not actually machined. It is common to pass cold headed blanks through a secondary grinding operation in order to produce the OD ground dowels.

It's important to understand the differences between cold heading and machining when designing a Solid Pin for an assembly as the manufacturing method directly impacts the design specifications (tolerances, geometry, & material) that can be assigned to the Solid Pin. The objective of this paper is to educate designers about the differences between cold heading and machining so that they understand how to design a Solid Pin that optimizes performance and reduces total manufactured cost of the assembly.

Machining Overview

Machining is the process of cutting raw material (rod) into a desired geometry using cutting tools. This operation is typically performed on a lathe. Machining produces scrap in the form of chips.

Cold Headed Overview

Cold heading is the process of forming raw material into a desired geometry by upsetting the material (wire) in one or more dies. The most common method of cold heading fasteners uses one die and two blows as this is sufficient for forming chamfers and heads. Dies provide cavities used to form the desired geometry, while a blow describes the physical process of upsetting material with a machine stroke. Additional dies and blows are needed as geometry becomes more complex. There are limitations to the amount of material that can be displaced per blow.

Cold heading sometimes includes a wire drawing process that work hardens the material, increasing both the yield and tensile strength. Machined pins produced with the same base material will have lower yield and tensile values because the material grain structure has been interrupted.

MANUFACTURING COMPARISON		
	Cold Heading	Machining
Quality of parts	✓	✓
Yield & tensile strength	✓	
Tight tolerances	✓	✓
Retention features	✓	✓
Scrap during manufacturing		✗
Complex part geometry		✓
Large length / diameter pin	✓	
Minimal tooling costs		✓
Short setup time		✓
Fast cycle time	✓	
Lowest overall Solid Pin cost	✓	
Lowest hole preparation costs	✓	

Table 1

Solid Pin Design Specifications & Manufacturing Capabilities

The first step in designing a joint is to establish the functional requirements of both host components and fasteners. Performance requirements should be achieved without over specifying the design. An ideal joint satisfies performance and quality requirements at the lowest possible cost. The information below will help designers understand the differences in capabilities between cold heading and machining as it pertains to design specifications for Solid Pins and host component holes.

Press Fit Pin Overview

Press fit dowels and straight pins are typically retained in the assembly by being pressed into holes that are smaller than the pin diameter. In most applications, interference must be limited to keep insertion forces within practical limits. The acceptable press fit for most metals (steel, brass, and aluminum) is 0.0125mm to 0.025mm (.0005" – .001") of material displacement. Since this tolerance threshold includes the sum of the tolerances of both the pin and hole diameter, pins must be precision machined and holes must be reamed and/or honed. This increases cycle time and manufacturing costs associated with hole preparation.

It's also important to recognize that free fit hinges do not require press fit holes and should not require pin diameter tolerances tighter than ± 0.025mm (± .001").

Tolerance

Typically, the outside diameter (OD) is the most critical Solid Pin dimension. Both cold heading and machining can achieve the tolerance specifications needed for the majority of Solid Pin applications. In fact, cold heading produces Solid Pins with OD total tolerances of 0.05mm (.002") (less than the thickness of a human hair). Machining can achieve tighter OD tolerances than cold heading, but this generally requires special ground OD rod. This should be avoided (if possible) as ground OD rod can be more than three times the cost of standard rod.

For Solid Pin length tolerances, machining and cold heading can achieve the same tolerance levels of approximately ± 0.25mm (± .010"). This varies by pin length.

The purpose of a chamfer is to allow for ease of assembly. A chamfer angle between 25° – 40° is suitable for the vast majority of Solid Pin applications and allows for maximum pin engagement. From a manufacturing standpoint, the optimal cutting angle (machining) is 45°, while the optimal forming angle (cold heading) is 30° or less.

TOLERANCE CAPABILITIES Solid Pin OD				
Manufacturing Method	**Raw Material**	**Raw Material Cost**	**Metric**	**Imperial**
Cold Heading	Wire	$	± 0.025mm	± .001"
Machining	Standard rod	$	± 0.0125mm	± .0005"
	Ground OD rod	$$$	± 0.0025mm	± .0001"

Table 2

SIDE VIEW - COLD HEADED PIN vs MACHINED PIN

Material

The most common materials for Solid Pins are carbon and stainless steels. Raw materials are available in different forms depending on whether pins will be machined (rod) or cold headed (wire). Commercially available material grades for rod and wire can differ. Rod is available in material grades best suited for machining, while wire is available in material grades suited for cold heading. Although material grades may differ, the important take away is that there are equivalent materials available for cold headed and machined Solid Pins. Hence, best engineering practices dictate that material specifications on drawings be relatively general if possible (i.e. carbon steel with hardness rating RC 27-33).

Table 3 shows examples of several common materials for cold heading and machining for reference.

EXAMPLES OF COMMON MATERIALS			
Material	**Benefit**	**Cold Heading**	**Machining**
Austenitic (nickel) stainless steel	Excellent corrosion resistance	305, 302 HQ	303
Martensitic (chrome) stainless steel	Corrosion resistant High shear strength High hardness	410	420
Low carbon steel	Versatile Low cost	1022	12L14
Alloy steel	High shear strength High hardness	6150, 4037	4150
Aluminum	Corrosion resistant Lightweight Lead free	5056	2024, 6061

Table 3

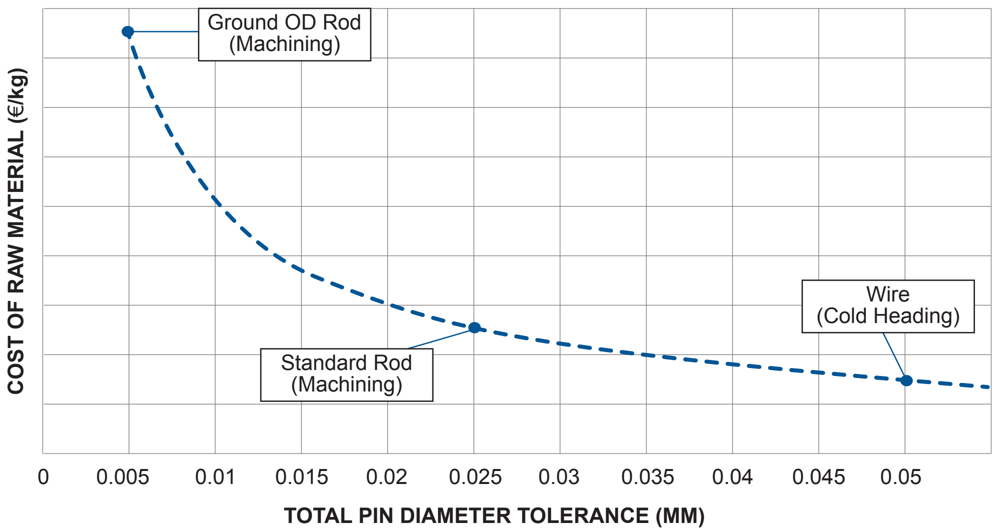
Note: This list contains some of the common available materials (others are available)

Cost Comparison – Cold Headed vs Machining

Machined Solid Pins are typically about ten times the cost of cold headed Solid Pins. Why are cold headed Solid Pins so much more cost effective?

- Cold heading produces Solid Pins at a rate of about 300 parts per minute (ppm), while machining yields approximately 4 ppm.
- Machining generates scrap. Hence, more raw material is needed to machine a Solid Pin than to cold head the same part. The only scrap generated during cold heading is that which is produced during set up.
- Ground OD rod can cost more than three times as much as standard rod used for machining.

PIN DIAMETER TOLERANCE vs RAW MATERIAL COSTS



Graph 1

TOP VIEW - COLD HEADED PIN vs MACHINED PIN

Although machining is more costly than cold heading, setup costs are significantly lower for machining. Companies that standardize on Solid Pin sizes are able to mitigate setup costs so there is a negligible cost impact to customers. However, setup costs can be significant for custom designs, especially at low volumes. *Table 4* outlines general differences between cold heading and machining setup.

SETUP COMPARISON New Solid Pin Design		
	Cold Heading	**Machining**
Setup time	6 - 12 hrs	2 - 4 hrs
Tooling costs	~€4,255	~€426

Table 4

Case Study

The case study below illustrates the differences between cold heading and machining a 3mm OD x 30mm long headed Solid Pin (blank dowel). As highlighted in the table below, raw material quantity and production rate (ppm) are the major factors for the drastic cost difference between cold heading and machining.

MANUFACTURING COMPARISON 25,000 pcs of 3mm x 30mm Headed Solid Pin			
Manufacturing Method		**Cold Heading**	**Machining**
Parts produced	#	25,000	25,000
Raw material description	-	Wire	Standard rod
Raw material needed (weight)	kg	8.6	26.3
Setup time	hrs	6 - 12	2 - 4
Total production time	hrs	1.4	104
Scrap	%	< 1%	65%
Diameter tolerance	mm	± 0.025mm	± 0.0125mm
Cost	-	✓	✗

Table 5

When to Use:

A Machined Solid Pin
- Low volume custom parts
- Highly critical alignment applications
- When functional requirements dictate complex pin geometry

A Cold Headed Solid Pin
- Majority of applications (as most do not require machined tolerances)
- Free fit axles / hinge pins where the pins are slip fit into place

Conclusion

Designers can optimize the performance and total manufactured cost of a joint by understanding the differences between cold headed and machined Solid Pins. Both manufacturing methods produce high quality, consistent parts. However, there are significant cost and capability differences between cold heading and machining. This paper can serve as a reference tool to assist designers with Solid Pin design specifications. However, it's recommended that manufacturers partner with industry experts in joining and assembling to identify the lowest cost solution for their assembly.

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