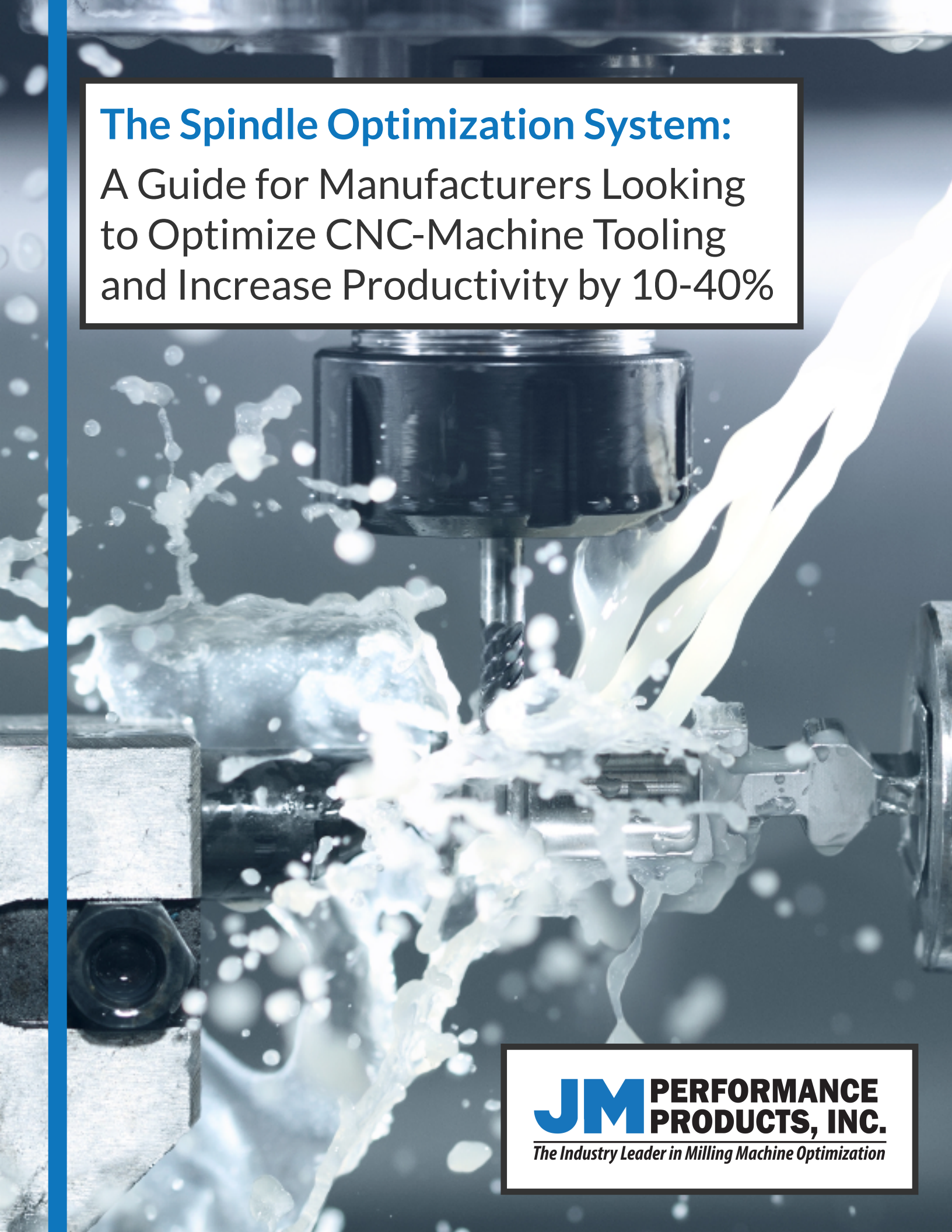

The Spindle Optimization System:

A Guide for Manufacturers Looking to Optimize CNC-Machine Tooling and Increase Productivity by 10-40%

JM PERFORMANCE PRODUCTS, INC.

The Industry Leader in Milling Machine Optimization

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Introduction: Toolholder Expansion (the unrecognized flaw that costs)

CNC milling using V-Flange tooling is flawed by design. Extensive testing has proven a standard retention knob has the potential to expand the toolholder when it is installed with as little as 20 ft/lbs. of torque. The extent of this expansion is variable, depending on the holder, the retention knob, and the installation practice.

CNC manufacturers operate in competitive markets and in order to be successful in these markets, they need to control costs wherever they can. An often-overlooked area is tooling. Toolholder expansion causes tooling variabilities and machining issues. In response to these issues, machinists must make adjustments, such as slowing down speed and feed rates.

Every adjustment adds cost to parts in terms of time and lost production. Reducing variables that impact spindle performance can extend tool life significantly and increase productivity by 10-40%.

Understanding the Impact of Toolholder Expansion Industry Wide

The average amount of toolholder expansion industry wide is 3.5 tenths, or 1/7th the width of a human hair. This miniscule amount of expansion is enough to inhibit complete toolholder taper to spindle contact and reduces tool life significantly.

Toolholder expansion also increases run-out, affects depths of cuts, forces reduction of speeds and feed rates, adversely affects finishes, tolerances, and repeatability, increases machine and spindle wear and tear, increases set-up times… all things that directly impact the number of parts produced.

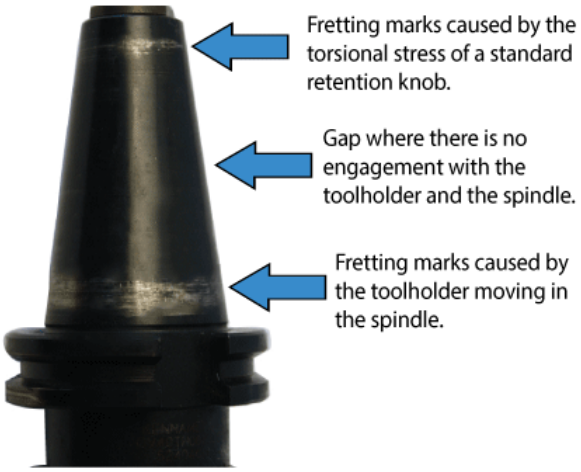
Common Symptoms that May Indicate an Underlying Tooling Problem

If you are experiencing any of the following, you may have a tooling problem.

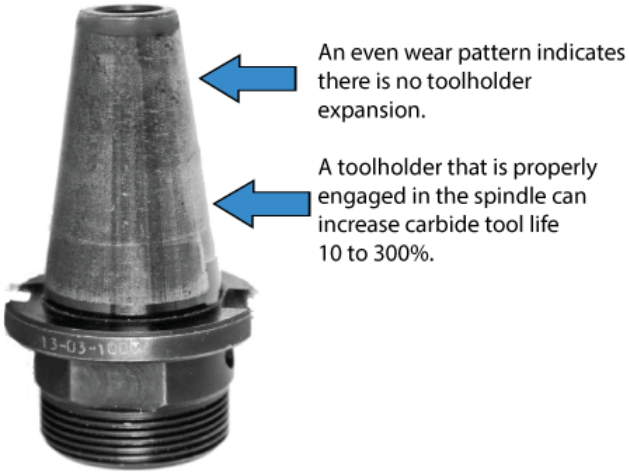
- Increased tooling costs;
- Vibration & chatter;
- Excessive harmonics on the mill;
- Lengthy set up times;
- Shortened tool life;
- Poor tolerances;
- The need for excessive polishing and finishing time;
- Run-out;
- Tool rigidity issues;
- Non-repeatability;
- Costly downtime.

Toolholder expansion can quite often be identified simply by looking at the wear patterns on the toolholder itself. Wear marks at the small end, and at the gauge line, with no wear in between are a clear indication of toolholder expansion.

Toolholder with uneven wear pattern



Toolholder with even wear pattern



Common Causes of Tooling Problems

Improper Installation

Improper installation procedures or applying excessive torque during retention knob installation will cause the toolholder to expand. This expansion creates a mismatch between the toolholder and the spindle, creating vibration and chatter due to movement of the holder within the spindle. This movement puts unnecessary stress on the spindle, the toolholder, and the tools, especially those with carbide tips and edges.

Excessive torque during installation of retention knobs can weaken the knob and cause premature breakage, resulting in possible damage to the toolholder, the workpiece, or the spindle. It can even harm the operator.

When not enough torque is applied during installation, a retention knob can back out of the toolholder or break prematurely due to metal fatigue. The knob needs to be torqued so that a proper pre-load is obtained to maximize retention knob performance and longevity.

It is imperative that proper sockets and a torque wrench are used in installation. It is also crucial that employees be educated on the proper installation process.

Improper Maintenance

There is a direct correlation between sound maintenance practices and mill performance.

Employing proper spindle maintenance practices can help increase productivity and extend the life of your tools and spindle.

Using the Wrong Tools

The retention knob is the interface between the tool and toolholder assembly and the spindle. It is the tool that the drawbar of the spindle grips to keep the holder in the spindle. Many companies will invest significant capital in the purchase of high-end, fast, multi-axis machines and equip their tool crib with the best tooling, but then buy the least expensive knobs they can find. In fact, the quality and design of the retention knob can completely negate the benefits of purchasing high-end tooling and machines.

Over the past 40 years, CNC machines and the tools used in them have evolved and advanced significantly. Mills run at faster rpm's, change tools in micro-seconds, and have more horsepower. Tools have become more specific to the materials and processes, with suggested faster speed and feed rate capabilities. The only thing that has not changed is the retention knob.

JM Performance Products developed the patented High Torque retention knobs to address this deficit and respond to the growing stresses of today's manufacturing.

How to Address and Prevent Tooling Problems: The Spindle Optimization System

The Spindle Optimization System requires manufacturers to establish, maintain, and enforce procedures and practices in their manufacturing environment that encompass **employee education, preventative maintenance with routine inspection, and the use of proper tooling** in all CNC milling machines.

Implementation of the system yields measurable results:

- Increased tool life; Improved spindle life;
- Reduced machine downtime;
- Faster set-up times; Increased feed rates;
- Increased RPS (speed) rates;
- Reduction of machine operator time per mill;
- Reduced run-out; Better finishes.

Employee Education

A full understanding by all employees involved in the set-up, maintenance, and operation of CNC mills is crucial to eliminate variables that can affect CNC spindle performance.

- Each employee involved in CNC milling should have access to training materials and/or training videos.
- Employees should have access to crucial information required for setup, which should include: the Manufacturers' drawbar force specifications, retention knobs required for each mill, tightening specifications, and maintenance schedules.
- Tools and retention knobs should be installed into toolholders using a Smart Tool-setter, torque wrench, and appropriate socket to eliminate over-torquing and under-torquing during installation.
- Employees should be aware of problem indicators (burnishing, run-out, chatter & vibration, excessive tool wear) so that appropriate countermeasures can be taken to quickly eliminate the problems.
- Employees should be knowledgeable about machine and tooling maintenance cycles to help reduce downtime.

Preventative Maintenance

The 5 Step CNC Mill Optimization Program

1. Clean the Spindle
2. Restore the Spindle
3. Inspect the Tool Holder
4. Monitor Drawbar Force
5. Install the right Retention Knob Correctly

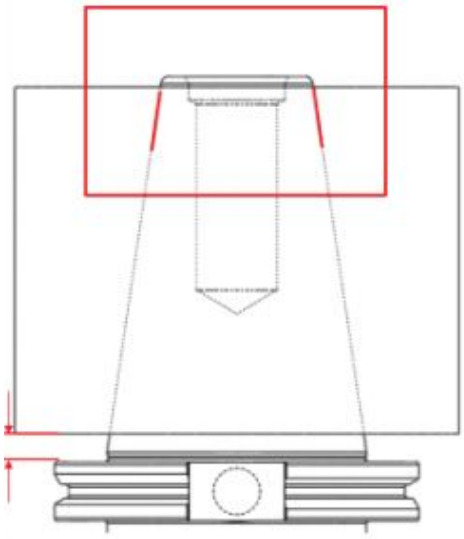
- ***Clean the Spindle***
  - Proper cleaning of the spindle eliminates the accumulation of grease, dirt, and other materials which cause build-up between the toolholder taper and the spindle. This build-up prevents proper seating of the toolholder taper with the spindle, causing variable positioning of the toolholder.

- ***Restore the Spindle***
  - Over time, grease, dirt, and materials become adhered to the spindle, affecting tooling performance. Regular routine maintenance of the spindle will extend the time between costly major spindle maintenance and regrinds by eliminating high spots caused by debris and rust. These high spots contribute to toolholder movement, while rust can pit the spindle.

- ***Monitor Drawbar Force***
  - Optimal drawbar force is essential, especially where high spindle speeds, precision boring, or heavy cutting forces are required. Scheduled testing and maintenance of long-term test records will aid in spindle drawbar problem diagnosis. Preemptive spindle maintenance aids in minimizing downtime and mitigates the risk and associated expense resulting from a machine crash caused by a dislodged tool. If the drawbar force is 80% or less of the machine manufacturer's recommendations, the Belleville washer stack needs to be rebuilt, and arrangements should be made with your service provider.

- ***Inspect Toolholders***
  - Improving the connection between the toolholder and the spindle is essential to improving tooling performance and to holding critical dimensions in production. Using a Taper Test Fixture, holders should be checked for hardness , wear, and expansion. Toolholders revealing 0.0002" or greater diameter expansion upon inspection should not be used and should be exchanged with the manufacturer.

The effects of an expanded Tool Holder



Diameter Expansion	Distance Short Of Full Engagement In Spindle
.00001458"	.00005"
.0000291"	.0001"
.0001455"	.0005"
.00029166"	.0010"
.0004374"	.0015"
.000582"	.0020"

As diameter increases the tool holder falls out of the spindle

- ***Resurface/Restore the Taper Toolholder***
  - Just as a clean spindle is essential for proper taper contact between the spindle and v-flange toolholder, the same applies to the toolholders. A build-up of oil, dirt, hardened grease and cutting fluid, along with nicks and dents on the holder can jeopardize this taper contact. The proper use of abrasive material to periodically resurface the v-flange toolholders will extend the life of the holder and the spindle.

- ***Inspect In-service Retention Knobs***
  - Retention knobs are not intended to last indefinitely. The normal life span is approximately 6,000 to 8,000 hours of use, which translates to 3 years of single shift usage, or 1 year of 24-hour use (3 shifts).
  - Retention knobs that have been in service for an undetermined period of time should be mag particle inspected to ensure they are not showing signs of stress, cracks, or fractures that could cause critical failure and damage to the machine and/or operator. Mag particle inspection requires removal of the retention knob. Removal and re-installation causes stress and possible failure of the knob. Once the retention knob is removed, it should be scrapped and replaced with a new knob to ensure physical integrity.

Use of Proper Tooling

High Torque Retention Knobs

When a toolholder is not fully engaged in the spindle, each time the cutting flute makes contact with the work piece it will try to move in the opposite direction, creating harmonics and chatter, excessive spindle wear, poor tool life, inability to maintain tolerances, and poor finishes.

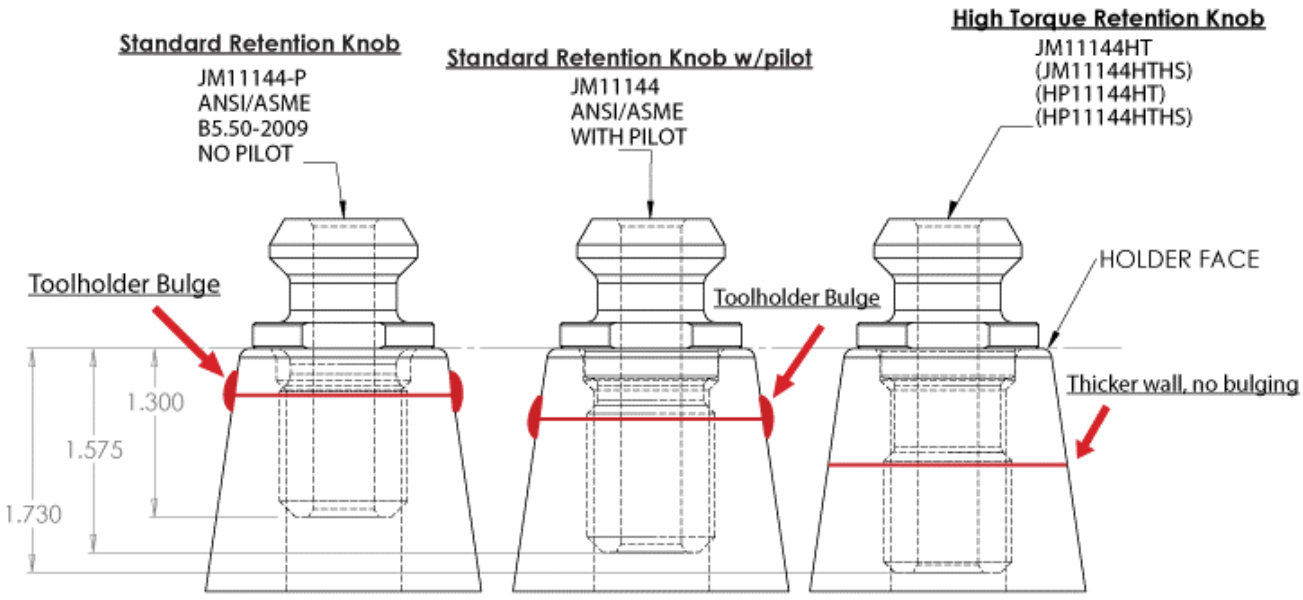
The threads of a standard retention knob will expand the top of the toolholder when installed. This is due to the force being applied to the first two threads at the top of the holder where the material is the thinnest. Patented High Torque Retention Knobs are designed to eliminate toolholder expansion, allowing the toolholder and the spindle to properly mate.

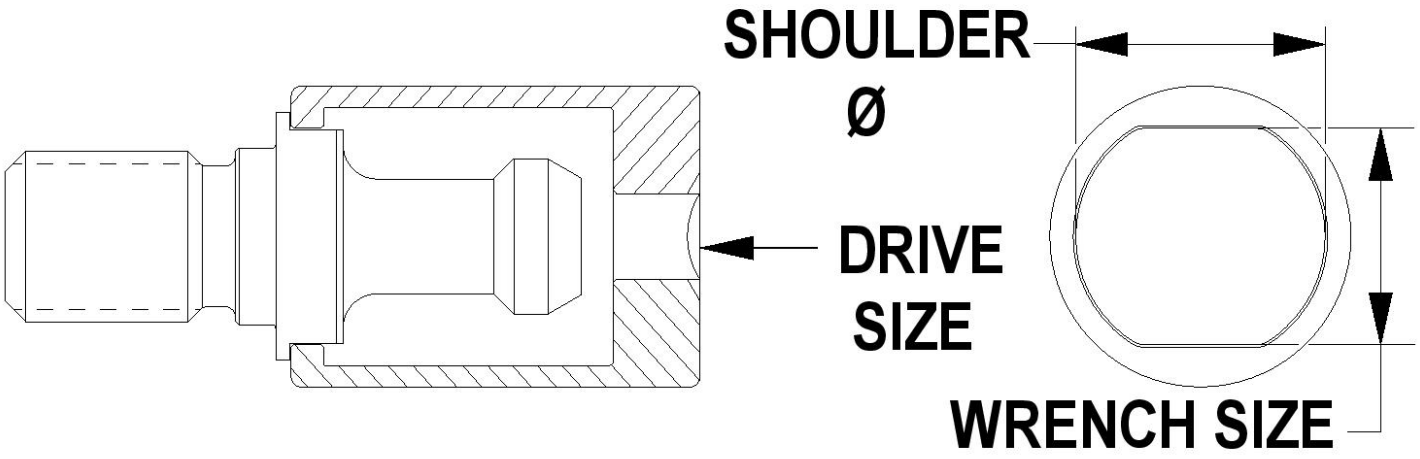
Dynamically balanced by design and made to fit existing toolholders, the High Torque knobs use a precision pilot which increases rigidity. A relief beneath the pilot forces the threads deeper into the thicker cross-section of the toolholder. Additionally, unlike other retention knobs, the High Torque knobs carry a calculated installation torque value which is a function of the taper size and the spindle drawbar force.

Manufactured from 8620H, 9310H and H13 steel, the knobs are shot peened to reduce stress, hard turned, and laser marked for traceability.

The High Torque Retention Knobs are proven to:

- Improve finishes;
- Increase tool life, toolholder, and spindle life;
- Increase rigidity;
- Improve tolerances;
- Increase productivity by allowing increases in feeds and speeds;
- Decrease harmonics, vibration, and chatter.





Retention Knob Sockets/Torque Wrenches/Adaptors

Proper installation of a retention knob into the toolholder is critical to maintain proper toolholder-to-spindle engagement. Improper retention knob installation can lead to stress on the knobs, causing breakage or damage to the toolholder and spindle.

Retention knob sockets are manufactured for DIN, ANSI, and JMTBA style knobs for 30, 40, 45, 50, and 60 taper sizes.

Torque wrenches are available in 10-80 ft/lbs and 20-150 ft/lbs.

1/2" and 3/8" drive torque wrenches are available in 10-100 ft/lbs.

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- Better finishes.

50M Retention Knob Socket

Instruments for Proper Installation and Maintenance

ClampForce Gage

Smart Tool Setter

Spindle Cleaning Kit

Restoration Kit

View Full Catalog

Outcomes from Implementation of the Spindle Optimization System

- Manufacturers have experienced tool life increases by 15% and more.
- They have seen their load meters drop, indicating the machine is using less power.
- Finishes are improved because of run-out elimination.
- Set-up times are reduced, which means tool changes are faster, so production breaks for retooling are reduced.
- Spindle regrinding and rebuilding is very expensive, but proper maintenance delays the need to regrind the spindle or maintain the Belleville washer stacks.
- Elimination of vibration and chatter, which impacts both the machine and the tools.
- Maintain tight tolerances without backing off the speed.
- Overall productivity is increased due to the ability to increase speeds and feed rates while maintaining improved tooling life.

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JM Performance Products, Inc. is the leading manufacturer of retention knobs, High Torque retention knobs, Spindle cleaners, and drawbar gages.
www.jmperformanceproducts.com

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GET STARTED