Machine Tool Spindle Bearing Lubrication: What to Know

Spindle bearings must be properly lubricated to maintain a film of lubricant between the rolling elements and the bearing raceways. Without lubrication, the rolling elements will have direct contact with the raceways, and this will result in heat, race deterioration, rolling element deterioration, cage disintegration, and ultimately bearing/spindle failure.

There are several methods of lubrication used for spindles. Below you will see the different types and the advantages and disadvantages to each method of machine tool spindle bearing lubrication:

Grease Lubrication

Grease packed spindles are some of the most commonly used spindles in machine tools today.

Greased for Life:

The majority of spindles are greased for life, meaning the only grease needed is that which is installed at the time of assembly. Grease manufacturers have brought their formulas to the point that the lubricating oils and the agents that carry them are resilient enough to last longer than the bearings expected duty cycle. However, bearing life can still be dramatically decreased by the introduction of outside influences such as coolant, high heat, metal chips, and grinding swarf—to name a few.

- **Advantages:** Little to no maintenance, proven technology, and no possibility of lubricator failure causing spindle damage.
- **Disadvantages:** Top speeds attainable are less than that of other lubrication methods, and an air purge system should be used to help decrease contamination issues.

Grease Maintained:

Spindles that are not greased for life and require additional grease to be added are uncommon and typically low speed.

- **Advantages:** Proven technology; it can be said that contaminants can be purged from the bearings with the addition of new grease.
- **Disadvantages:** Top speeds attainable are much less than that of other lubrication methods; over lubrication is common causing heat and bearing failure; maintenance schedules must be adhered to; and higher probability of the wrong grease being put into the spindle.

Grease Injected:

Grease injected spindles allow for a small portion of grease to be injected into the bearings at a rate determined by the machine tool manufacturer. This is commonly done with grease cartridges that are pneumatically controlled by the machine PLC. This allows for new grease to replace what is currently in the bearing and the ability to use different grease types in a spindle that may have a combination of angular contact bearings and roller bearings.

- **Advantages:** Some contamination prevention capacity.
- **Disadvantages:** Grease cartridge is expense (some cost in excess of $1500.00); grease tends to build up in the bearing causing heat and premature failure; clogging of the grease passageways occurs causing one bearing to be under lubricated and the other to fail from over lubrication; and there is prohibitive price and availability for the replacement bearings.
Oil Lubrication

Oil lubrication is performed by external equipment and usually carried to the spindle via tubing. These systems use liquid oil, such as ISO 32 or equivalent, which is delivered to the spindle in a stream of air. There are a few different delivery systems, each having its own characteristics:

Oil Mist:

One of the first spindle oil delivery systems used for spindles was oil mist. This method uses compressed air to atomize the oil and carry it to the spindle. This oil laden air is pumped through the spindle flowing through the bearings. Some of the oil “wets out” on the bearings while some of it is released to the atmosphere from the front and rear of the spindle. The system consists of an air regulator attached to a ventury. The ventury often has a clear bubble at the top with a tube that shows the frequency of the drops per minute. For spindles, an average rate is 20 drops per minute (dpm) but can vary from 5 dpm to 80 dpm depending on the application. Too high of a rate causes heat and bearing skidding and too low a rate does not allow for enough of an oil film between the rolling elements and raceways.

- **Advantages:** Basic system with low initial cost that requires little maintenance.
- **Disadvantages:** Creates an oil fog that contaminates the air; over time the venturies can clog causing a lack of lube situation and spindle failure; and over time the excess oil will settle on everything in the room.

Oil Injection or Air over Oil:

Oil injection systems are comprised of three main parts: Air filter/regulator, oil pump, and injector block. Most manufacturers (we recommend Bijur) have a panel with the entire system installed on it. The pump contains the oil reservoir and is set to activate at predetermined intervals. It produces enough pressure to activate the injector cartridges in the mixing block. The mixing block produces a finely metered drop of oil, usually between .01 and .05 cc’s each time the pump activates. The oil drop is then pushed down the wall of the tubing to the bearings by a steady stream of air. This system requires the oil lines be run very close to the bearings, unlike oil mist systems.

- **Advantages:** Enables high speed operation of the spindle; uses up to 1/3\textsuperscript{rd} less oil than oil mist systems; decreased external environmental impact because the oil is not delivered in atomized form; and used oil can be collected—keeping it out of the environment.
- **Disadvantages:** Initial cost is slightly higher than oil mist systems; if left unused for a period of time, the oil will settle in the lines at the lowest points; this method requires a warm up period to redistribute the oil in the lines; and there is no good way to warn against injector failure (not a common occurrence).

Expert Hints:

- Coil tubing to keep settling oil uniformly distributed
- Purge oil mixing block after service
- Oil should be quarter sized blotch on paper after several minutes to verify oil distribution
- Use clear plastic tubing to see oil flowing
• Replace filters regularly
• Keep lubricants sealed and contaminate free
• Use only clean, dry filtered air

**Under Raceway Lubrication (Makino):**
This method lubricates the bearings through holes in the inner races of the bearing. Oil is pumped through the shaft, through the bearing, and then recovered by a vacuum system.

- **Advantages:** Helps to keep a constant shaft temperature.
- **Disadvantages:** The spindle bearings become proprietary to the OEM, leaving very little service options to the end user; the pumping and vacuum systems are complex and prone to failure; air pressures and vacuum pressures must be calibrated to tight specifications or spindle failure will result; and this requires paying OEM service rates for the removal and installation of the spindle.

**Hydrostatic and Hydrodynamic**
Hydrostatic bearings and hydrodynamic bearings are fluid film bearings that rely on a film of oil to create clearance between the moving and stationary elements.

Hydrostatic bearings employ a positive pressure supply that maintains clearance between the rotating stationary elements. With a hydrostatically lubricated bearing, the lubrication is introduced under pressure between the moving surfaces. Hydrostatic bearing spindles feature high stiffness and long bearing life, and are often used for fine machining and finishing. Because hydrostatic lubrication does not depend on relative motion to maintain the lubrication film, it can accommodate heavy loads at low speeds.

A hydrodynamic bearing is typically a low-clearance assembly that relies on a film of oil that develops clearance while the spindle is rotating.

- **Advantages:** Excellent accuracy; commonly used in grinding applications; and boasts long life if maintained properly.
- **Disadvantages:** Lower load capacity; and bearing failure repair requires manufacturing of new parts that are not readily available.