BREAKTHROUGH IN MOTOR BEARING TECHNOLOGY

Motorized Bearing Technology – The Next Generation

Spindles are high-speed shaft rotation systems in which different bearing systems are integrated. The demand for rotation systems with lower vibration yet higher maximum rotation speed, bred by modern technological developments, has led to the design of air-bearing spindles. A new, sophisticated technology for the design and manufacture of spindles – the "Motorized Bearing Technology" – enables the integration of significantly enhanced air bearings. This technology was developed at the **Colibri** laboratories (patent pending) and is used in numerous applications, such as semiconductor dicing, PCB drilling, fine milling, grinding and more.

The spindle is made up of several elements: bearings (radial and axial), motor and stator, tool mounting system, tracking system and cooling system.

Spindles are divisible into two main groups:

- Ball-bearing spindles
- Air-bearing spindles

The ball-bearing spindle is used primarily in applications that do not require high accuracy or high-speed rotation (above 15,000 rpm). In contrast, the air-bearing spindle allows higher-speed rotation and higher accuracy, with lower vibration of the rotating shaft.

Colibri, a member of the **Iscar** Group, specializes in the manufacture of two types of air-bearing spindles:

- Aerostatic – compressed air
- Aerodynamic – atmospheric pressure

These spindles are sold to a variety of industries, including the semi-conductor, PCB, digital pre-press, machining, testing system and other industries.

Figure 1: **Colibri** spindle

Bearing Placement Principles:

- A spindle is constructed from two axial bearings positioned ahead of two radial bearings
- While the shaft distance between the two axial bearings is reduced, fixed and accurate gaps must be kept, regardless of possible thermal influences
- In order to reduce axial expansion at the shaft end, where the tool is mounted, the axial bearing is usually placed at a distance from the spindle motor
- Thermal changes due to electric-eddy currents in the motor system and friction forces operating on the bearings may result in axial expansion
- The air-bearing stiffness depends on the geometric size of the bearing. However, producing longer and bigger bearings is far from simple or efficient nor is it cost effective
- The distance between the front and rear radial bearings is influenced by the shaft-end stiffness, bearing stiffness and self-frequencies

These principles are implemented via three main design concepts: conservative design, second-generation design, and **Colibri**'s unique motorized bearing technology design, called the MBT design method.

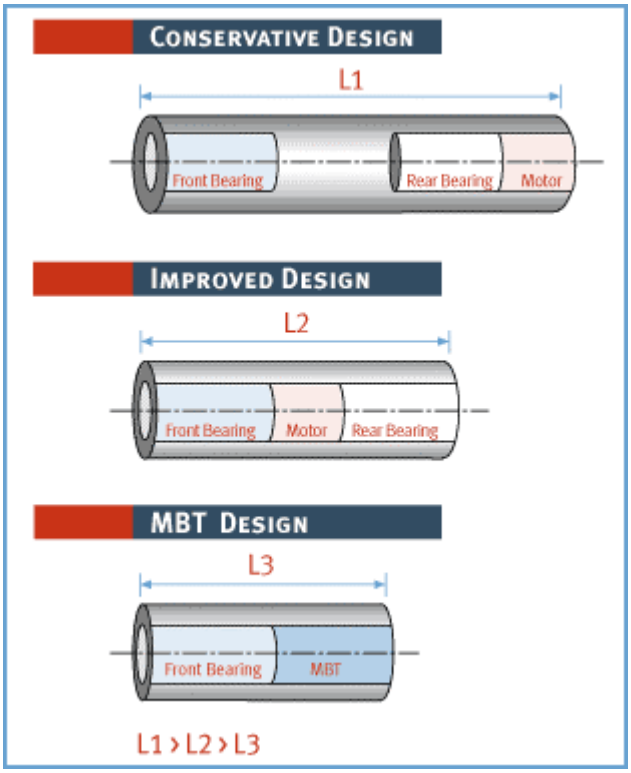

Figure 2: Comparison between the three spindle design concepts

Conservative Design* – *Cantilever Motor: The spindle is constructed in the following order: shaft end, mounting system, front axial bearing, rear axial bearing, front radial bearing, gap, rear radial bearing, electrical motor and tracking system (Figure 2). This design has numerous drawbacks, such as high production costs, a longer shaft with lower self-frequencies, bigger weight and high inertia moment, complicating the spindle's dynamic balancing.

Spindle manufacturers require spindles with high stiffness and high load capacity. In air-bearing spindles, this translates into longer bearings with a bigger diameter. Positioning the motor to the rear, behind the radial bearings, places an additional load on the rotor, necessitating planning for improved bearing stiffness and load capacity. Increased stiffness can be achieved by enlarging the radial bearings or reducing the gaps between the bearings. Either way, this improves the bearing stiffness but causes difficulties in the spindle design and production.

Second Generation* – *Improved Conservative Design: In a more advanced design, the electrical motor is positioned in the gap between the two radial bearings (Figure 2), which eliminates the drawback presented by the placement of the motor behind the rear radial bearing. **Colibri** has used this innovative method to design numerous spindles, while improving spindle performance at higher rotation speeds.

Third Generation* – *MBT Design: In **Colibri**'s unique design (Figure 2) – based on its motorized bearing technology in which the bearing and motor are integrated in a single unit – the electrical motor also serves as the radial bearing, allowing a shorter length of the radial bearings. The motorized bearing technology can be implemented in either the radial or axial bearings, depending on the type of motor.

The MBT design technology offers the following advantages:

- Smaller geometric dimensions
- Reduced spindle weight
- Extended shaft cycle lifetime
- Higher rotation speed
- Higher self-frequencies – lower vibration amplitudes
- Increase in bearing stiffness and maximum load capacity
- Lower maintenance cost
- Simplification of automatic tool replacement system
- Lower production costs

Figure 3: Small spindle for hard-disk applications

These advantages are significant for small, precision systems requiring the use of an accurate and reliable spindle, such as the hard disk of a home computer or portable computer (Figure 3). The current demand for increased disk rotation speed dictates a transition from ball bearings to aerodynamic bearings. The **Colibri** spindle technology allows production of a miniaturized bearing and motor system, enabling integration of the system in other compact systems.

Colibri's extensive knowledge and experience in spindle technology, accumulated over the past few years, enables low-cost design and production of compact, high-speed spindles with added value performance.